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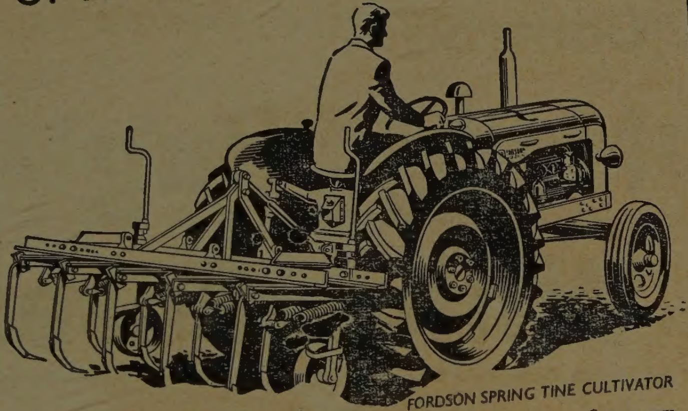

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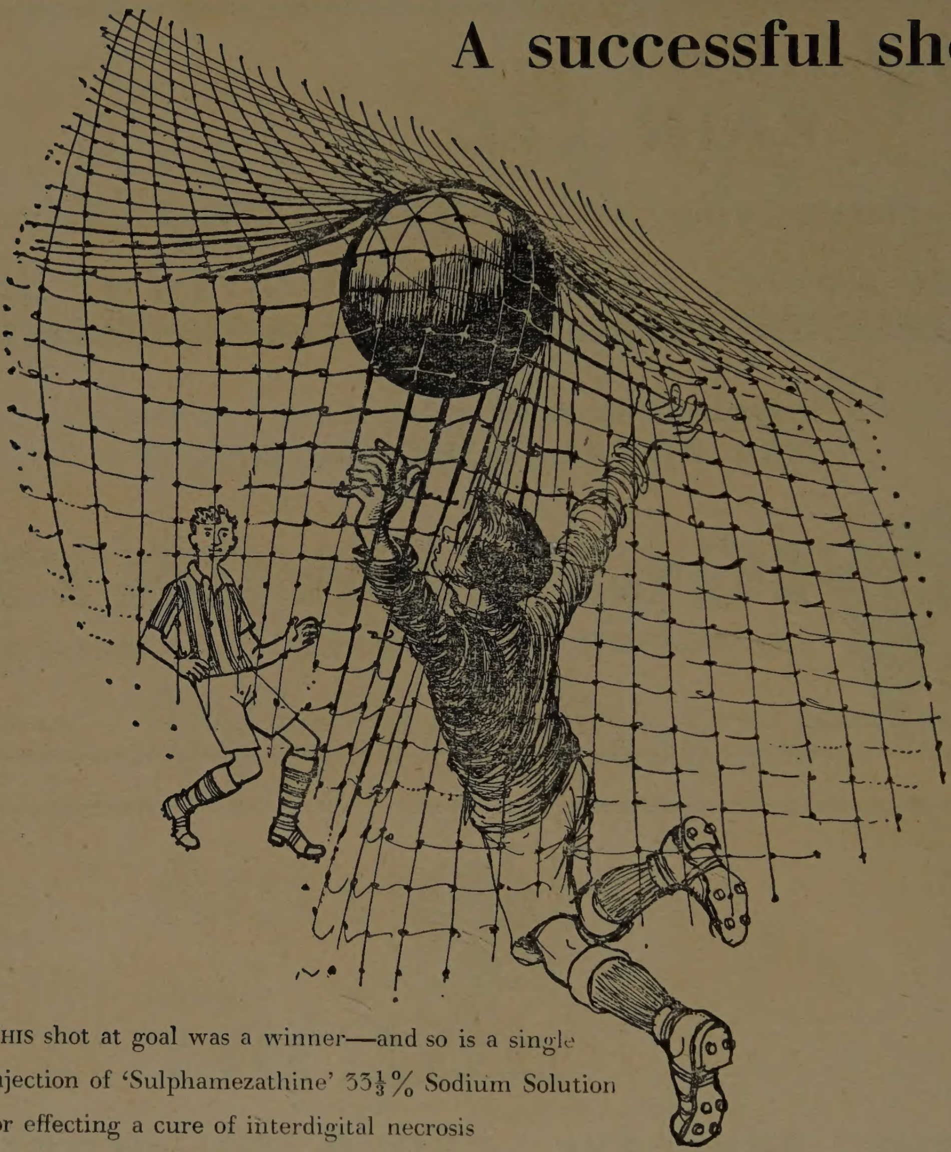

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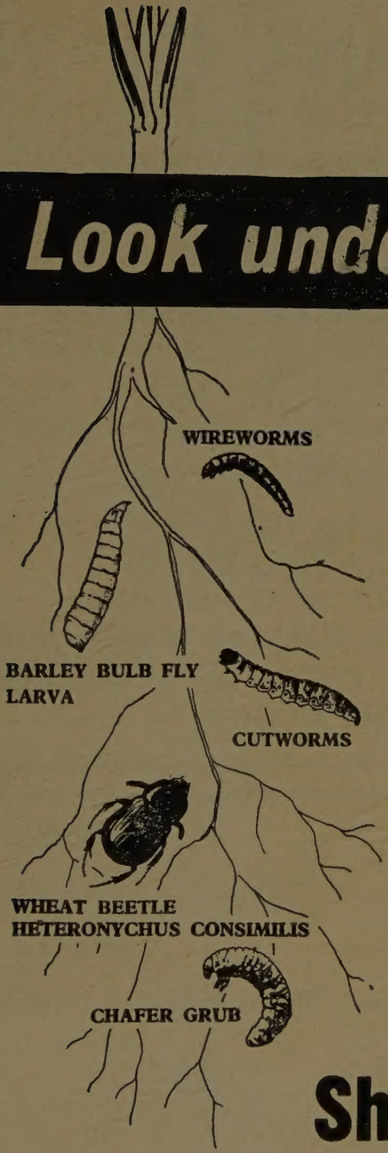

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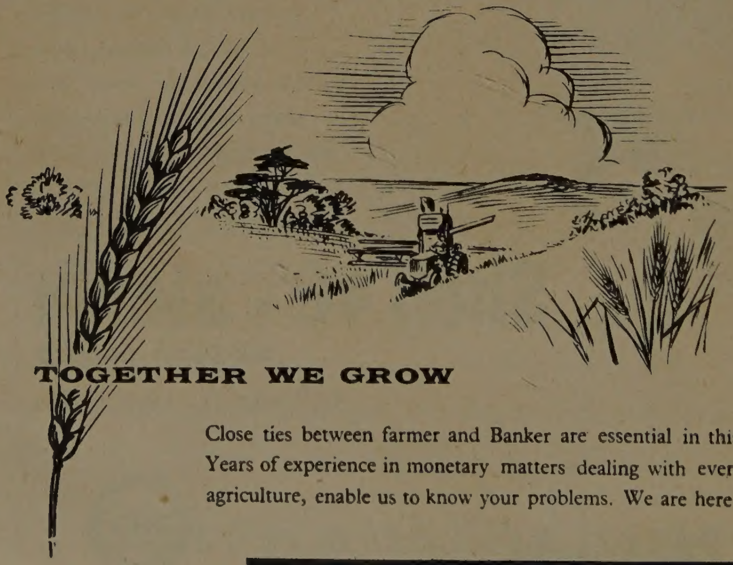

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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THE EAST AFRICAN AGRICULTURAL JOURNAL

A FEEDING TRIAL WITH SISAL WASTE

By **P. J. Frank, Veterinary Department Experimental Station, Naivasha, Kenya**

(*Received for publication on 13th December, 1956*)

During the past few years the price of sisal fibre has dropped so steeply that the sisal industry is looking for means to increase the financial return from its estates. At present, only 4 per cent of the leaf is recovered as fibre, and to improve this extraction rate some estates are using a machine for the secondary removal of fibre, in addition to the preliminary decortication. The material produced after this second removal is known as sisal waste, and consists mainly of the leaf pulp together with a small amount of fibre.

Another method of increasing the return from the estates is to make full use of the many acres of grazing which are available by running beef herds. These herds would not only be a source of additional revenue, but would also improve the fertility of the land. As an aid to solving the problem of keeping these herds in condition during periods of dry weather Mr. Rodseth, of East African Sisal Ltd., Ruiru, who had already produced excellent results on his own estate, asked the Veterinary Department to carry out a feeding trial on sisal waste, to determine its palatability, its value as a feedingstuff, and whether, if fed in large quantities, it produced any ill-effects.

TABLE I.—CHEMICAL ANALYSIS

	D.M. %	Crude P. %	Fat %	Fibre %	Ash %	Nitrogen Free Extract Soluble Carbohydrate
Dry Sisal Waste ..	84·4	3·2	1·9	29·2	6·7	43·4
Wet Sisal Waste ..	15·7	·6	·3	3·6	1·6	9·6
Wet Prickly Pear ..	16·5	·8	·3	2·3	3·4	9·7

From Table I it is clear that sisal waste and prickly pear are very similar materials. Morrison states that prickly pear has proved itself to be a useful feed in the desert regions of Mexico and America, where it provides emergency forage during periods of drought; its feeding value was assessed as 6 lb. of prickly pear being equal to 1 lb. of sorghum hay.

EXPERIMENTAL LAYOUT

Three groups of four high-grade Ayrshire cows were used. Each group was similar for number of lactations and the number of days in milk. (*See* Table II.)

TABLE II.—AVERAGE NO. OF DAYS IN MILK AT START OF TRIAL

	Average No. of Lactations	Average Period in milk-days
Group I	3·5	29·75
Group II	3·5	31·0
Group III	3·5	31·0

Each group was fed three different rations in rotation; ration A was the control ration; ration B contained 15 lb. daily of sisal waste, and ration C contained 30 lb. daily of sisal waste. These are given in Table III.

TABLE III.—RATIONS

		S.E.	D.P.
Theoretical requirements for maintenance and 1½ gallons milk ..		9·6	1·47
Ration A ..	30 lb. Hay (Rhodes Grass)	7·80	·990
	6 lb. Lucerne Hay	1·68	·582
		9·48	1·572
Ration B ..	26 lb. Hay (Rhodes Grass)	6·76	·858
	5 lb. Lucerne Hay	1·40	·485
	15 lb. Fresh Sisal Waste	1·40	·060
		9·56	1·403
Ration C ..	16 lb. Hay (Rhodes Grass)	4·16	·528
	9 lb. Lucerne Hay	2·52	·873
	30 lb. Fresh Sisal Waste	2·80	·120
		9·48	1·521

Any cow producing over 1½ gallons of milk daily was fed a balanced production ration of 4 lb. per gallon.

All the cows were tethered during the trial, and were unable to obtain any food other than the rations mentioned above. Water was available to the cows at all times.

The feeding programme is set out in Table IV.

TABLE IV.—FEEDING PROGRAMME

	Group I	Group II	Group III
1st 10-day period..	Ration A	Ration B	Ration C
2nd 10-day period	Ration B	Ration C	Ration A
3rd 10-day period	Ration C	Ration A	Ration B

The cows received their rations for seven days before entering into the 10-day recording period. This "settling in" period was necessary as the cattle took a few days to become used to the sisal waste. In this way feed refusals were almost eliminated for the duration of the recording period.

RESULTS OF TRIAL

Tables V and VI summarize the results of the trial.

DISCUSSION OF RESULTS

The results of the trial have been analysed statistically, and there is no significant variation in the milk production of the groups. No comparison can be made between the groups, as their average milk production was not equal at the beginning of the trial. It should be noted that all the cows reached their maximum yield during the first 10-day trial period, and that during the second and third 10-day periods, one would expect the yield to drop in accordance with the lactation curve. This reaches its maximum at about six weeks after calving, and then drops at the rate of 6 per cent per month. Also, the cows were tied up in the open during a period of rather wet and cold weather. These points would account for the small drop in milk production which occurred during the period of the trial.

Table VI shows that there were very slight differences between the average milk production and butterfat percentages of the cows whilst being fed on rations A, B and C.

Observations.—(1) The rations fed were composed of dry forage except for the sisal waste, in order to simulate the conditions of grazing when sisal waste is most likely to prove useful, i.e. dry weather.

(2) The sisal waste became unpalatable to stock if it was more than 48 hours old.

(3) Although it was impossible to weigh the animals at the beginning and end of the trial, the cattle appeared to remain in very good condition throughout the trial, and there seemed to be no variation in weight. The milk was smelt at intervals, and no undesirable taint was detected.

TABLE V.—RESULTS OF TRIAL

	GROUP I			GROUP II			GROUP III		
	Daily Average lb. Milk	Daily Average lb. Butterfat	Butterfat %	Daily Average lb. Milk	Daily Average lb. Butterfat	Butterfat %	Daily Average lb. Milk	Daily Average lb. Butterfat	Butterfat %
		RATION A			RATION B			RATION C	
1st 10-day period	24·4	·98	4·02	21·6	·82	3·8	26·4	1·25	4·75
		RATION B			RATION C			RATION A	
2nd 10-day period	22·4	·86	3·88	20·3	·75	3·68	24·3	1·01	4·15
		RATION C			RATION A			RATION B	
3rd 10-day period	21·5	·78	3·64	18·2	·72	3·98	21·4	·889	4·15

TABLE VI.—AVERAGE DAILY YIELD AND BUTTERFAT PERCENTAGE FOR RATIONS A, B AND C

	Ration A	Ration B	Ration C
Average Daily Yield	22·3 lb.	21·8 lb.	22·7 lb.
Average Butterfat per cent ..	4·05%	3·94%	4·02%

The milk of each cow was recorded twice daily during the 10-day trial period; butterfat samples were taken at the beginning and end of each trial period.

CONCLUSIONS

The trial has shown that dairy cows can be fed up to 30 lb. per day of sisal waste, without any ill-effects on milk production or on the cows health. The material is succulent and readily taken by stock, once they are accustomed to it. Its succulence would make it a useful feed during the dry weather on estates where water supplies are limited. Owing to its high moisture content and low feeding value, it could only be used economically on sisal estates, where little or no transport is involved in taking it to the cattle.

This feeding trial was conducted on dairy cows, in order to obtain an indication of the value of sisal waste as quickly as possible because of the great expense of transporting the material from Ruiru to Naivasha daily. But its greatest value would be to those sisal estates which run beef cattle on the grass strips between the sisal plants; it would provide a solution to the difficulty of maintaining these herds in condition during the dry weather, thus reducing the time for these animals to reach slaughter weight and also reducing the area of the estate to be allocated for grazing.

THE FOURTH FORESTRY COURSE, 1956

The fourth E.A.A.F.R.O. Forestry Course was held in November, 1956, and was attended by 12 delegates from the four East African territories, and from British Somaliland. Thus in the four courses so far, 64 forest officers have been to Muguga. The courses were started in 1952 because extensive touring by specialists in the East African territories had shown that in nursery and plantation practice very varying results were being obtained.

Further, the E.A.A.F.R.O. experimental work in forest nursery and plantation establishment practice and the effect of varying local soil and other conditions were beginning to show results. It was realized that local work throughout the territories could be improved, and for this a better understanding of the basic principles was needed. These courses have been asked for by the territories through the Forest Research Co-ordinating Committee, and a fifth course is planned for 1957.

This fourth course lasted for a week and started with three days of discussions and practical demonstrations in the E.A.A.F.R.O. Forest Research Nursery and Experimental Plantations at Muguga. The whole course then moved up to Molo in Londiani Forest Division and spent two days of practical demonstrations and discussions in some of Kenya's softwood plantations.

The scope of the course was widened as during the year Mr. May, E.A.A.F.R.O. Horticulturist, has been touring the territories giving local talks on nursery work. This meant that at the course less time need be spent on nursery work and more time on plantation establishment and tending problems. Talks were given by various E.A.A.F.R.O. specialists and other outside officers, and to all we are most grateful for their help.

The benefits of such courses are many, for they give a chance to groups of technical officers, many of whom lead very lonely lives, to get together and discuss their problems. These problems are usually interterritorial, and as one officer put it "these courses and discussions tend to break down parochiality and make local officers raise their sights". The course finished with a final discussion session at which the delegates were asked to criticize the course and offer suggestions for improvement so that the fifth course may be even better.

We very much appreciate the efforts of all those who helped to make the course a success both in work and socially. In particular, we are grateful to the Chief Conservator of Forests of Kenya and his staff who made it possible to have two such interesting and instructive days at Molo.

The moral of the course is that however well we are carrying out our work, it is possible that we could do better, and this object can only be achieved if the basic principles of the work are understood and applied to local conditions. Much of the work of the present-day forest officer is non-technical drudgery, and we hope that we have managed to stimulate interest in some of those unlucky ones whose daily work often bears very little relation to their technical training.

A. L. GRIFFITH.

NOTES ON ANIMAL DISEASES

XI—VIRUS DISEASES OF PIGS*

By G. R. Scott, Department of Veterinary Services, Kenya

(*Received for publication on 23rd February, 1957*)

Twelve virus diseases are known to affect domestic pigs and five of them are present in Kenya. The latter are discussed fully in this paper. Brief notes on the other infections are included because of the increased facility for the introduction of exotic diseases occasioned by modern forms of transport. In addition, atrophic rhinitis is discussed although the ætiology of the disease is still unknown.

FOOT-AND-MOUTH DISEASE

Foot-and-mouth disease is an acute, febrile, very highly contagious disease of ruminants and swine characterized by the formation of blisters in the mucosa of the mouth, in the skin, especially between and above the claws of the feet and occasionally on the teats and udder. The incubation period is 2–5 days, the morbidity rate approaches 100 per cent, and the case mortality rate, especially in suckling pigs may be as high as 60 per cent. Foot-and-mouth disease affecting pigs was first reported in Kenya in 1918 in the Annual Report of the Department of Agriculture.

Aetiology.—Seven immunologically distinct types of foot-and-mouth disease virus are known, namely Vallee O, Vallee A, Waldman C, SAT.1, SAT.2, SAT.3 and Asia 1. Vallee O, Vallee A and SAT.2 have been isolated from Kenya livestock. The virus is one of the smallest infectious agents known. Outside the animal body the virus is very resistant and survives under favourable conditions for weeks in materials like hay, bran, flour, sugar and hair. The virus is resistant to many chemicals. However, strong alkalis rapidly inactivate the virus and caustic soda and sodium carbonate solutions are the disinfectants of choice.

Natural host range.—Foot-and-mouth disease affects all ruminants and swine. Game animals naturally susceptible are buffalo, eland, impala, kudu, sable antelope, waterbuck and warthog. Hedgehogs have been found naturally infected in England. Man is rarely attacked. Sometimes, in outbreaks the strain of virus involved showed a prediliction for one species. For example, epizootics have occurred in pigs only, in-contact cattle being unaffected.

Experimental host range.—The important laboratory hosts are guinea-pigs, suckling mice, fowl embryos and tissue cultures. Camels have been infected experimentally.

Transmission.—Foot - and - mouth disease virus is the most infectious pathogenic agent known. Natural transmission may either be by direct contact between infected and healthy animals or by indirect contact between healthy animals and contaminated objects. Outbreaks in pigs are frequently associated with the feeding of unsterilized swill containing infected meat scraps. The feeding of unboiled skim milk from infected cows has also initiated the disease in pigs. Birds can spread the disease. People from infected farms should never be allowed on to clean premises. The classic example of this type of dissemination was the outbreak of foot-and-mouth disease in Saskatchewan, Canada, in 1951, unwittingly caused by an immigrant who had left an infected farm in Western Germany 15 days before.

Symptoms.—Sudden deaths without any premonitory signs have been recorded in unweaned pigs. Usually the first sign is a rise in temperature followed by the development of blisters on the coronary bands of the feet. In addition blisters may develop on the front and back of the rim of the snout. Mouth lesions are uncommon in pigs. The blister ruptures within a few hours leaving raw, red erosions with ragged edges. The prominent symptom is lameness. The lesion persists for about a week at the coronary band and the horn separates from the underlying tissues. The growth of new horn from the coronary band slowly pushes down the old separated horn so that the pig appears to be wearing clogs. Secondary bacterial infection is common.

Post-mortem findings.—Deaths occur mainly in young animals. In addition to the obvious superficial lesions there is the characteristic

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"tiger heart", so called because of the grey-white or yellowish streaks evident in the heart muscle. Acute gastro-enteritis is common in young pigs.

Diagnosis.—The clinical findings, and if young pigs are affected, the post-mortem findings, are diagnostic in an area known to be infected with foot-and-mouth disease. The type of virus involved can only be determined by laboratory techniques and the tissue of choice is a piece of the ragged edge of a freshly ruptured blister. This should be forwarded to the Veterinary Research Laboratory, Kabete, in 50 per cent glycerol-buffer phosphate.

Treatment.—Specific therapeutic treatment is not available. Recovery is hastened by clean surroundings and the use of mild astringent and antiseptic lotions.

Immunity.—Recovery from the natural disease is followed by type specific immunity only. In other words, recovered animals are fully susceptible to the other types of the virus. The duration of immunity in pigs is less than ten months. Foot-and-mouth disease vaccines have given disappointing results in pigs, especially if the viruses used in the preparation of the vaccines are of bovine origin. At present, in Kenya, vaccination of pigs is not recommended. Foot-and-mouth disease antiserum given to in-contact pigs has been reported to limit the infection rate to 10–40 per cent.

Prevention.—Foot-and-mouth disease is a scheduled disease in Kenya. When an outbreak occurs in a district very strict control measures must be instituted. All contact with neighbouring farms must cease and swill and milk must be boiled before being fed to pigs. Alkalis are the best disinfectant and a 4 per cent solution of Magadi soda (sodium carbonate) is recommended.

VESICULAR EXANTHEMA

Vesicular exanthema of swine has been reported only in the Americas. The course of the disease in pigs is identical to that of foot-and-mouth disease. At least five distinct types of the virus are known. Cattle, sheep, goats and guinea-pigs are not susceptible.

VESICULAR STOMATITIS

Vesicular stomatitis is primarily a disease of horses. Natural outbreaks sometimes occur in cattle. The disease does not occur in Kenya. The lesions are identical to those of foot-and-mouth disease. Two types of virus are known. Adult pigs can be infected by experimental inoculation but only young pigs can be infected by contact. Guinea-pigs are susceptible to vesicular stomatitis.

SWINE POX

Swine pox is a disease of pigs characterized by the development of pocks along the belly and the inside of the legs. The disease is not contagious but is transmitted by lice. Two forms of the disease are described. One is an acute disease affecting pigs of all ages and the mortality is high. The other is a mild, non-fatal disease of young pigs, especially suckling pigs. The acute form has not been recorded in Kenya. Piercy (1951) observed the mild disease at Kitale, Naivasha and Rongai.

Aetiology.—The antigenic relationships between the viruses of the two forms of the disease and the pox viruses of other animals is ill-defined. The virus of the acute form appears to be related to cowpox. The virus of the mild disease is unrelated. Little is known either about the physical characteristics of the viruses or their resistance to adverse environmental factors. Sporadic observations suggest that they are less stable than most other pox viruses. South American workers believe that the virus can survive, in the absence of susceptible pigs, for at lease one year in pig lice.

Transmission.—Swine pox is not transmitted by contact. Artificial inoculation of susceptible pigs readily induces the disease and, in nature, the pig louse (*Hæmatopinus suis*) is the principal vector. In Australia, spread by mosquitoes has been suspected.

Symptoms.—The incubation period after artificial infection is 3–5 days. The first lesions are small red spots which enlarge and develop into hard grey scabs varying in size from a half to one inch in diameter. The removal of a scab in the early stages reveals a raw red area of skin. The scabs usually drop off in a few days and the whole process is completed within two weeks. Systemic symptoms are absent unless secondary bacterial infection supervenes. The case mortality rate is low.

Diagnosis.—The clinical findings are diagnostic. If confirmation of the diagnosis is desired, scabs in 50 per cent glycerol-saline should be forwarded to Kabete.

Treatment.—Spontaneous recovery is expected and, unless secondary infection supervenes, treatment is not advised.

Immunity.—Recovered pigs are immune for life.

Prevention.—The elimination of lice and mosquito control will limit the spread of the disease.

RABIES

Rabies is a fatal infectious disease of man, animals and birds characterized by marked nervous disturbances which progress to paralysis and death. Rabies occurs in Kenya particularly in Nyanza Province but cases affecting pigs have yet to be recorded.

Aetiology.—Rabies is a neurotropic virus and develops within the nervous system. The virus is also present in other tissues and transmission can only occur if the salivary glands excrete the virus in the saliva. Virus multiplication is associated with the development of cytoplasmic inclusions, known as Negri bodies, in nerve cells. The inclusions are specific for rabies and are of great significance in diagnosis.

The virus, if protected from drying, is resistant. Infected brain tissue in neutral glycerol will retain its infectivity for several weeks at room temperature and for several months in the refrigerator. If frozen, the infectivity of the tissue is retained for at least two years. The virus resists putrefaction but is readily killed by chemicals such as formalin, phenol, chloroform, ether, potassium permanganate and even soft soap.

Transmission.—The disease is transmitted by the bites of rabid animals. Virus, excreted in the saliva, is literally inoculated through the bite wound. However, only a proportion of rabid animals are infectious. The commonest disseminators are infected dogs and wild carnivores. In Central and South America the vampire bat is the principal spreader of the disease. In North America and South-eastern Europe, several species of insectivorous bats have been found infected but not fatally. The question is posed as to whether or not rabies is only a natural disease of bats and the fatal disease in other species represents an accidental "spill over" irrelevant in the survival of the virus.

Symptoms.—The incubation period is 3–6 weeks and consequently the original wound may have healed before symptoms become apparent. Affected pigs run around aimlessly, ferociously root up the litter or the ground and, if the wound is still present, bite it savagely. They are very aggressive and dangerous. Paralysis may supervene before death. The course of the disease after symptoms are noticeable is short and never more than one week.

Post-mortem findings.—Lesions at death are non-specific.

Diagnosis.—In a rabies enzootic area, any pigs exhibiting nervous derangement should be regarded as having rabies until proven otherwise. They should be isolated and severely confined. Animals surviving for ten days are not infected with rabies.

Treatment.—Treatment should not be attempted. Other exposed animals should either be destroyed or held in quarantine for at least six months.

Immunity.—Infected animals seldom survive and the grade of immunity following recovery is an academic question. A suitable vaccine for pigs has yet to be developed.

Prevention.—Rabies is a scheduled disease in Kenya. In East Africa the jackal is regarded as the prime reservoir. Control measures should be on a continental basis and must embrace registration and restriction of dog movement, vaccination of dogs with avianized vaccine, and destruction of vectors.

PSEUDO-RABIES

Pseudo-rabies, or Ausjesky's disease, has an almost world-wide distribution but, so far, the disease has not been recognized in Kenya. Pigs are the primary host of the virus and in adult animals only a mild febrile illness occurs. In young stock losses may be as high as 90 per cent. Nervous signs predominate. The intense itching of the skin which characterizes the disease in cattle, dogs and cats, is absent in pigs. Recovered animals are immune.

TESCHEN DISEASE

Teschen disease is another nervous disease of pigs. The condition occurs mainly in Central Europe but has been reported in Madagascar. The acute form of the disease is most frequently observed and is associated with a case mortality rate of 90–100 per cent. The disease should be suspected if nervous symptoms are associated with a high fever.

AFRICAN SWINE FEVER

African swine fever (ASF) is a highly contagious peracute fatal disease of domestic pigs characterized by fever, pronounced hæmorrhages of the lymph glands, kidneys, and mucosa of the alimentary tract. Clinically and pathologically the disease resembles European swine fever or American hog cholera. The diseases are antigenically distinct and a further fundamental difference is the failure of ASF to stimulate antibodies in affected pigs. Recovered pigs are not immune and instead become indefinite carriers of the virus. European swine fever, on the other hand induces a permanent immunity. The morbidity rate approaches 100 per cent. The natural incubation period is 7–12 days. The incubation period after parenteral inoculation may be as short as 24 hours. The case mortality rate approaches 100 per cent.

ASF is confined to Africa and was first recognized in East Africa by Montgomery in 1910. The primary host of the virus is the warthog in which an inapparent infection occurs. Infections of domestic pigs are epizootiological accidents and the disease is self-limiting.

Aetiology.—Only one type of ASF is known. Earlier references to antigenic instability of the virus stemmed from the failure to recognize that immunity does not develop in infected pigs. ASF, therefore, belongs to the Francis group 1, i.e. virus diseases in which virus infection persists but immunity does not. The physical properties of the virus are unknown except that it is readily inactivated by ultra-violet light. The virus is very resistant and survives prolonged periods of storage. For example, infected blood was still virulent after 18 months at room temperature.

Natural host range.—The natural host of ASF virus is the warthog. Bushpigs have also been incriminated. Domestic pigs are very susceptible.

Experimental host range.—In the laboratory ASF virus has been propagated in rabbits, fowl embryos and tissue cultures.

Transmission.—Between domestic pigs transmission is by direct contact or contact with contaminated fomites. Transmission between the true natural hosts, the warthogs, and domestic pigs is probably similar but has yet to be proved.

Symptoms.—Infected warthogs and bushpigs are seldom clinically ill. Virus isolations have been made from apparently healthy animals. In domestic pigs the first sign is a marked rise in temperature to 105° or greater. The thermal reaction is maintained throughout the acute phase of the disease which may be as short as 48 hours or may extend to five days. A sudden drop in temperature often precedes death. Infected pigs are dull and refuse to eat. They lie huddled in a corner under the bedding and are disinclined to move. If made to stand up, they sway and arch their backs. Respirations are accelerated. Early constipation may be replaced by blood-stained diarrhoea. Reddening of the skin, especially on the ears, snout, abdomen and legs, is usually pronounced. Death normally supervenes within five days of the first rise in temperature. The very low percentage of survivors are extremely emaciated and their prominent bed-sores heal slowly. Their former condition is never regained and their eventual death appears to be associated with a marked chronic pericarditis. Surviving pigs are lifelong carriers of the virus.

In an outbreak the first sign of trouble usually is the discovery of one or two dead pigs followed a week or so later by a few more deaths and, then a further week later, by many cases. Every outbreak in Kenya has been linked to the presence of warthogs or bushpigs.

Post-mortem findings.—The outstanding lesions are hæmorrhagic. The skin has a patchy or diffuse purplish colour. The mesenteric and body lymph glands are invariably hæmorrhagic which may be so extensive as to present a bluish-black colour to the whole gland suggesting that they are blood clots. Fluid is present in the thoracic and abdominal cavities The heart is studded with hæmorrhages varying from pinpoints up to large blotches. The lungs are œdematous. The spleen is swollen. The kidneys are intensely hæmorrhagic throughout. Hæmorrhages with blood clots are often seen in the stomach, occasionally in the small intestine and frequently in the large intestine. Ulcerations are also commonly observed. The post-mortem findings may vary considerably in the individual animals and if death occurs shortly after the onset of the disease, lesions at post mortem may be conspicuous by their absence. The "button ulcers" of chronic European-type disease are not a feature of African swine fever.

Diagnosis.—The history, clinical and post-mortem findings are diagnostic. Differentiation from European swine fever can only be done at the laboratory to which blood in OCG solution should be sent.

Treatment.—Treatment is not advised.

Immunity.—Recovered pigs are not immune and are actually carriers of the virus, consequently vaccines are unlikely to be developed.

Prevention.—In Kenya, ASF is a scheduled disease. During the period 1913 to 1944, 60 outbreaks were recorded. In 1944 a slaughter policy was adopted and since then only four outbreaks have occurred. All pigs on affected premises are slaughtered. The carcasses are burned and the premises disinfected. Compensation is paid to the owners. By 1948 pig production in Kenya had reached a stage at which there was an exportable surplus. Rules were designed to safeguard importing countries and pigs for export can only be drawn from specifically defined areas in which no outbreaks of ASF have occurred during the previous ten years. In addition, legislation was introduced whereby all domestic pigs had to be enclosed at all times. Destruction of the natural host of the virus was encouraged by the payment of a bounty for warthog snouts.

European Swine Fever

European swine fever or American hog cholera is a highly contagious disease of pigs which may be acute, sub-acute or chronic. The acute form of the disease is characterized by hæmorrhages of the internal organs and is clinically and pathologically indistinguishable from African swine fever. The sub-acute and chronic forms are associated with diphtheritic lesions especially in the large intestine. Recovered pigs are solidly immune. European swine fever, therefore belongs to the Francis group 2, i.e. a disease in which immunity persists and the virus does not. European swine fever is of considerable economic importance in Europe and the U.S.A. Reports from South Africa suggest that both European swine fever and ASF have occurred there. European swine fever is a scheduled disease in Kenya but has never been recognized in East Africa. The disease has been eradicated from Canada and Australia by adoption of a rigid slaughter policy.

Virus Pneumonia

Virus pneumonia of pigs (VPP) is a chronic disease characterized by pneumonia, a high morbidity rate and a low mortality. Immunity does not develop and affected pigs remain carriers for life. Affected pigs do not thrive as well as normal pigs. Current reports indicate that the condition is widespread throughout the main pig-raising areas of the world. Between 1945 and 1951, 50 per cent of the lungs of 700,000 pigs slaughtered at one factory in England showed evidence of VPP. The disease was first reported in Kenya by Plowright in 1953, and was also shown to be widespread in the country.

Aetiology.—Knowledge of the physical characteristics of the virus is scanty. The size is estimated to be about 250 millimicrons. VPP survives storage for prolonged periods at deep freeze temperatures but not at refrigerator temperatures.

Natural host range.—Only the domestic pig has been incriminated. The susceptibility of African wild pig is unknown.

Experimental host range.—A suitable laboratory host has yet to be found and investigations have been hindered because of the difficulty of ensuring supplies of VPP-free pigs.

Transmission.—Spread of VPP is by direct contact between infected and healthy pigs. Once the disease is established in a herd it tends to remain indefinitely in an enzootic form. The infection is perpetuated by piglets becoming infected from their dams and the virus can thus persist from one generation to the next. Young pigs, not infected by their dams, commonly contract the disease from other young pigs with which they are mixed after weaning.

Symptoms.—The natural incubation period is two to three weeks. The experimental incubation period following parenteral, intratracheal, inoculation of the virus is one to two weeks. Occasionally the disease is manifested by an acute attack but the vast majority of the infections are chronic. When infection is first introduced into a susceptible herd the onset is often dramatic. Pigs of all ages are affected and the case mortality rate may be high, especially in young stock. Respiratory distress is evident. The surviving pigs become carriers of the virus and thereafter the chronic form of the disease occurs. Typically, piglets show infection at three to six weeks of age or two to three weeks after weaning. The first sign is a transient diarrhoea followed by a dry cough which is characteristic. The cough may disappear after some weeks or may persist indefinitely, and is most marked when the animal is forcibly exercised. Affected pigs do not thrive but usually the loss in condition is so insidious as to be unrecognized. Therein lies the danger. A number of pigs previously infected as piglets may suddenly develop acute symptoms of pneumonia at 19 to 26 weeks of age. The animals are prostrate, "thump", and have a rust-coloured nasal discharge. The temperature is high. The majority recover. The relapse is believed to be caused by a breakdown of the earlier lesions and is associated with a marked increase of secondary bacteria.

Post-mortem findings.—The lesions are confined to the ventral portion of the lungs, particularly in the cardiac and apical lobes. They are usually plum-coloured but sometimes are greyish. The pneumonic areas are clearly demarcated from normal lung tissue. Pleurisy and pericarditis can occur. The bronchial and mediastinal lymph glands are swollen and œdematous. The extent of the lesions found at post mortem is no indication of the severity of the disease during the preceding months.

Pigs which die during relapses have in the lung yellow necrotic areas which teem with bacteria. Pleurisy is always present.

Diagnosis.—The clinical, epizootiological and post-mortem findings are diagnostic.

Treatment.—Symptomatic relief can be obtained in acute cases and relapses by the control of secondary bacterial invaders by antibiotics. The virus itself can be inhibited by full courses of sulphonamides, streptomycin or aureomycin.

Immunity.—Like ASF, the virus of VPP belongs to the Francis group 1. The virus persists in infected animals and immunity never develops. Effective vaccines are therefore unlikely to be evolved.

Prevention.—Herds must be self-maintained to remain free of infection. Any introductions should be from herds proved to be free of VPP by means of a slaughter test extending over several months.

The disease can be eradicated from infected herds by rearing litters in strict isolation. If symptoms of pneumonia developed the sow as well as the piglets are slaughtered. VPP-free herds have also been developed from infected herds by removing the piglets immediately after birth or by Cæsarean section and hand-rearing them. The simplest method in commercial herds is to sell all the existing stocks and replace with stock from known VPP-free herds.

Swine Influenza

Swine influenza is an acute febrile disease of pigs characterized by sudden onset, coughing and a peculiar type of abdominal breathing associated with broncho-pneumonia. The incubation period is short, varying from one to three days. The duration of illness is two to six days. The morbidity rate is high and the case mortality rate can vary from 10–100 per cent. The disease first appeared in Kenya in 1935 at Elburgon (Daubney, 1936). This outbreak in adult pigs was associated with a case mortality rate of less than 2 per cent. The infection spread widely throughout the Colony and for several months the mortality rate in litters exceeded 70 per cent.

Aetiology.—The virus of swine influenza has close affinities with the virus of the human disease. Both possess the property of hæmagglutination. During the acute stage of the disease swine influenza virus can be recovered readily from the respiratory tract but not from other viscera. Outside and inside the host the virus can exist for over a year in a masked state in either lungworm larvæ, inside earthworms or in lungworms in the pig.

Natural host range.—The natural hosts of the virus are the domestic pig and lungworms.

Experimental host range.—Mice and ferrets are very susceptible to infection. The virus also multiplies in the fowl embryo.

Transmission.—The virus is maintained between outbreaks in lungworms. Under conditions of stress the virus is stimulated to activity and clinical infection of pigs results. In an outbreak transmission is by direct contact between diseased and healthy animals.

Symptoms.—The onset is sudden. The affected pigs are prostrated, fevered and depressed. Abdominal breathing is marked and spasms of coughing common. The illness lasts a few days and recovery is as sudden as the onset. Deaths occur during the acute phase of the disease. Survivors frequently develop a chronic cough.

Post-mortem findings.—The mucus membranes of the respiratory tract are inflamed and coated with a white tenacious mucus which may be bloodstained. The lungs are pneumonic. The bronchial and mediastinal lymph glands are enlarged and œdematous.

Diagnosis.—The history and clinical findings are diagnostic. The rapidity of the course of the disease distinguishes it from VPP, and virus isolation by inoculating suspect material into mice or fowl embryos will confirm.

Treatment.—Treatment is not recommended.

Immunity.—Recovered pigs are immune. In this, swine influenza differs markedly from VPP. The duration of immunity is not well defined but in human influenza the immunity persists only for a few months.

A formalinized lung tissue vaccine was prepared at Kabete in the 'thirties and used with some success. Recently in Britain an adjuvant vaccine has shown promise.

Prevention.—The spread of the disease is best controlled by strict isolation of the farrowing sows.

TRANSMISSIBLE GASTRO-ENTERITIS

Transmissible gastro-enteritis is an acute disease of suckling pigs characterized by profuse diarrhoea, vomiting, rapid loss of body weight and high mortality. The disease is widespread in the United States of America and probably occurs in Great Britain and Europe. It has not been recognized in Kenya.

ATROPHIC RHINITIS

Atrophic rhinitis is characterized by the partial or complete disappearance and decalcification of the nasal turbinate bones. Clinically the commonest sign is naso-facial deformity. Sneezing and bleeding from the nose may be noted. Young animals are usually affected. The cause is unknown but is believed to be an infectious agent, probably a virus.

The disease has been known in Europe for more than 100 years and is serious in the Landrace breed of pigs. As yet, the condition has not been recorded in Africa.

Symptoms.—The natural incubation period is about two weeks. At first sneezing or snuffling is confined to one or two pigs but soon spreads to the rest of the litter. Nasal discharge varies in amount and if severe the affected piglets breathe through the mouth. Conjunctivitis is present and tears are common. The majority of piglets recover at this stage. Chronically affected pigs continue sneezing and there is a progressive deformity of the snout. The flow of tears in chronic cases produces a brown comma-shaped stain which extends down the inner canthus of the eye. Otherwise the affected animals are in fairly good bodily condition.

Post-mortem findings.—Piglets dying in the acute phase of the disease show little on post mortem. Chronic cases show a variable degree of deformity which is most easily seen if the snout is sawn across behind the first molar. In the normal pig the turbinate bones should virtually fill the nasal cavity. In affected pigs the turbinates have disappeared and only a narrow fold of mucus membrane remains.

Diagnosis.—The disease is insidious and if often not recognized. The identification of chronic cases is diagnostic.

Treatment.—Treatment is not advised because of the very real danger of propagating the agent in clinically recovered animals.

Prevention.—A stamping-out policy by slaughter is recommended. Importations from North America and Europe should be kept under observation until the second generation pigs have proved to be healthy.

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HAMPSHIRE DOWN SHEEP SUPREME OVER ALL BREEDS AT SMITHFIELD SHOW

A pen of three Hampshire Down ewe lambs took the Supreme Championship over all breeds at Smithfield Show held at Earls Court, London, last year. They did this in competition with 188 entries from 24 different breeds and crosses. This is the third consecutive year that Hampshire Downs have won this supreme award and in each case the winning pen has been shown by the same exhibitor, Sir William Rootes, who is also well known in the motor industry.

In the carcass competitions—the largest and finest yet staged at Smithfield—a carcass of Hampshire Down lamb from Messrs. P. Stewart Tory and Sons' famous Shapwick flock at Blandford, Dorset, took second prize in a class of 41 entries from all breeds.

Messrs. Tory are now completing several consignments of breeding sheep ordered for Kenya, Tanganyika and other countries. They are largely used for crossing with native sheep and the improvement in the subsequent lamb crop is very marked and is causing considerable interest among sheep farmers in many countries.

These sales arise largely from Messrs. Torys' initiative in flying lambs to the Kenya Royal Show this year in which they took supreme championship.

THE EFFECTS OF DEPTH OF PLANTING EXOTIC PINES AT MUGUGA (KENYA)

By A. L. Griffith, Silviculturist, East African Agriculture and Forestry Research Organization

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SUMMARY

Six experiments carried out at the E.A.A.F.R.O. Estate Muguga (Kenya) over a period of three years with the species *Pinus patula*, *P. radiata* and *P. leiophylla*, have shown that deep planting (burying up to 50 per cent of the stem) produced no deleterious effect on the survival percentage and resulted in a stimulation of height growth in the first year of the order of 20 per cent. It is possible that the beneficial effects of deep planting may be greater in areas which have even more unreliable climates.

The trends of the results are confirmed by the work of Slocum and Maki in the N. Carolina Piedmont of the S.E. of the U.S.A. with the species *P. taeda*, *P. rigida*, *P. virginiana* and *P. echinata*.

INTRODUCTION

Instructions on tree planting given to students at the forest schools and universities always stress the need for planting the seedlings at the same depth at which they grew in the nursery. In practice, however, very wide departures from this "ideal" planting often occur, particularly where labour is scarce and untrained. In East Africa the tendency to deep planting was very noticeable especially during the troubled early days of the Emergency It was therefore decided to investigate what effect this deep planting had on establishment and early growth. It was curious that the tendency was towards deep planting and cases of shallow planting were rarely seen. It was very necessary to test this effect of depth of planting as several European investigations as reported by Toumey and Korstian [1] state that poor results are likely to follow deep planting. This work in Europe was largely in Germany and Austria and the species concerned were Norway spruce and Scots pine.

In addition, in most parts of East Africa the rainfall is unreliable in both total and season and it was desired to test whether deep planting was beneficial in a year when rainfall was deficient or irregular. These experiments are part of a series on plantation establishment technique which include the date of planting [2] the effect of storage and exposure of the plants in the interval between lifting in the nursery and planting in the field [3], the rainfall reliability [4] and the measurement of soil moisture at planting time [5].

DESCRIPTION OF THE LOCALITY

The experiments were carried out in the E.A.A.F.R.O. Estate at Muguga at an elevation of about 6,800 ft., roughly 15 miles N.W. of Nairobi. The average annual rainfall has been approximately 36 in. over the past 33 years. This total is erratic and in the past five years has ranged from 22.5 in. to 57.6 in. The average number of rainy days per year (days on which more than 0.01 in. of rain fell) over the past five years has been 122 and has only varied from 107 to 144.

The climatic year naturally divides itself into five seasons. They are:—

First dry season. January and February (2.8 in.).

Long rains season. March, April and May (20.8 in.).

Mist season. June, July and August (2.7 in.).

Second dry season. September and October (3.1 in.).

Short rains season. November and December (7.0 in.).

The underlying rock is Limuru quartz trachyte, a recent volcanic rock. The soil is a dark red or chocolate-brown loam of good fertility and depth. The pH is about 6.0 and the top few inches contain a considerable quantity of humus. The site is exposed to the prevalent easterly winds which are hot and dry from January to March.

The forest was originally indigenous evergreen in type containing a fair stand of quite large *Juniperus procera*, some of the stumps of which still remain. It was clear-felled and planted with wattle (*Acacia mollisima*) in 1929 to 1931. The wattle crop standing when the experiments were started was of the second and third rotations.

DESCRIPTION OF THE EXPERIMENTS

On each experimental site the wattle was felled and the brushwood burned on the site. As the experiments were short-term ones and the results were assessed at the end of the first year after planting, the spacing was close, at three by three feet. The experimental areas were clean-weeded throughout the first year, at the end of which they were measured for height growth and survival percentage, and visually estimated for vigour, colour, etc. The initial heights were measured immediately after planting. The experiments have been two per year for the last three years, the species used being *Pinus patula, P. radiata* and *P. leiophylla.* In each experiment there were three treatments (*a*) plants planted normally (*b*) plants planted 2 in. deeper than they were in the nursery and (*c*) plants planted 4 in. deeper than they were in the nursery. Over the six experiments the sets of plants initially varied from 8 to 16 in. high so that burying 4 in. of stem in treatment (*c*) was in effect burying from 25 to 50 per cent of the stem of the plant. Each treatment was of 100 plants comparable in size, age, etc. The 100 plants of each treatment were arranged in 10 sets of 10 and in each experiment the treatments were in stratified random sets of 2 sets of 10 plants each. This was done to avoid maldistribution of treatments on the ground, which can so easily occur if unrestricted randomization is done in forest experiments, which of necessity must occupy a much larger area than is usual in agricultural experiments. The plants were planted in pits roughly 1 ft. cube.

The nursery stock used was in general about nine months old and about 8 to 9 in. high for *P. patula,* about 9 in. high for *P. leiophylla* and 12 to 16 in. high for *P. radiata.* All stock was raised in boxes in Muguga Standard Mixture of soil to which a basic application of N.P.K. had been added [6].

DISCUSSION

The six experiments over three years with three species show no significant difference in survival percentage due to deep planting. All the experiments show a stimulation of height growth due to deep planting of some 10 to 30 per cent varying with the species and the climate of the year. In all experiments also at the end of the year the deep planting appeared to have produced sturdier plants. The averaged relative mean height growth of the three species at the end of the first year after planting were:—

Treatment	*P. radiata*	*P. patula*	*P. leiophylla*
Normal planting	100	100	100
Buried 2 in. ..	107	107	115
Buried 4 in. ..	114	122	130

Thus at Muguga deep planting has resulted in a gain in growth and vigour and in no deleterious effects on survival percentage. It is of interest that very similar results indeed have been obtained by Slocum and Maki in the N. Carolina Piedmont of the U.S.A. [7]. Working with *P. taeda, P. rigida* var. *serotina, P. virginiana* and *P. echinata* they found that deep planting up to half of the stem resulted in no loss of stocking and produced a height growth stimulation of some 10 to 33 per cent.

INDICATIONS

Although further repetition is required, it appears that in the climate of Muguga deep planting is likely to be beneficial in that in six experiments with three species over three years there has been no deleterious effect on survival and a stimulation of height growth of the order of 20 per cent. It is probable that the beneficial effects of deep planting (i.e. putting the seedling roots into the deeper layers of the soil which dry out much slower in the event of a break in the rains or their early cessation) may be even greater in areas with a climate less reliable than that of Muguga.

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WASTAGE IN THE HERD

By J. Anderson, Veterinary Department, Kenya

(*Received for publication 2nd October, 1956*)

The length of productive life of the cow and the useful life of the bull are obviously of great economic importance. Milk Marketing Board records show that only about one cow in eight lives to reach her best performance in the 6th lactation or thereabouts. The longer a cow is in use, the greater production there is to carry costs of rearing or purchase, and more calves are produced for heifer replacements, giving a better chance of effective culling. Also, the fewer replacements that are required each year, the higher the degree of selection of female stock that can be made.

Dinsdale and Winter (1955) pointed out that the costs of rearing dairy heifers to calving entails a lock-up of capital for approximately three years before this capital yields any return. This is a long time to wait in comparison with other ways of using working capital. Reducing the need for herd replacements by extending the herd-life of cows would reduce the amount of capital so locked up, and any reduction in the number of heifers needed for herd replacement would release resources in land, labour, seed, feeds and so on for use in ways yielding quicker rates of return.

The annual replacement percentage is the number of heifers, drafted annually into a herd or breed as first calvers, expressed as a percentage of the total number of actively producing cows in the herd or breed. In effect, it is the number required annually to make good the losses. A high annual replacement figure does not permit adequate selection of the heifers that are drafted in annually to maintain the female stock. In addition to having an immediate economic effect, a lowering of the replacement percentage would, by giving the breeder a better chance to select his female stock, have an even greater subsequent effect in the general improvement of cattle. Also, disposal of bulls at an early age does not permit the breeder to employ the progeny test, and long life is necessary to make full use of superior bulls.

Methods of investigating this problem have included the study of wastage; the average age of cows at calving, from which the annual replacement percentage of cows can be calculated; and the incidence of disease, which focuses attention on the important causes of disposals from herds, and on aspects requiring further investigation and research. In fact, as Smith and Robinson (1931) stated, to concentrate research upon problems concerning which the present state of agriculture most requires its aid.

The percentage of all removals from dairy herds varies from about 19 to 34 (Lawson, 1929; Roberts, 1929; Smith and Robinson, 1931; Wright, 1933; Rose, 1938; Sanders, 1939; Baltzer, 1940; Pettit, 1940; MacGregor, 1941; Chitty, 1943; Williams, 1943; Pryce-Howell, 1945; Pegg and Rice, 1949; Phillips, 1949; Clark and Paul, 1953; Withers, 1955), which gives an average productive life of from about three to six years; but, since a large proportion of such animals will be drafted into other herds (i.e. their productive life is not necessarily ended), many figures in which they are included cannot be used in estimating the total length of productive or milking life of the average cow; they are of use only for calculating the length of life of animals in the one herd.

The National Institute for Research in Dairying (1933) and Sanders (1939) distinguished between total wastage and "true" wastage, assuming that cows disposed of under the headings "trade" and low milk yield are sold into other dairy herds and are destined therefore to appear later in some category of "true" wastage. In Britain and America, some 20 per cent of disposals are due to sale for milk and a varying percentage for poor milk yield. The average length of total productive life, calculated from "true" wastage was 4.7 years (N.I.R.D., 1933) and 5.8 years (Sanders, 1939). From Table I the percentage of disposals, less trade surplus, is 17.4 to 22.4, which gives an average productive life of 4.5 to 5.7 years.

Hewitt (1934) stated that 16 per cent of females must be replaced each year; with a birthrate of 93 per cent, there are about 48 heifer calves of which 36, or 75, per cent, are reared, which means that in addition to the 16 which are required for replacements there remain 20 available for replacing low yielders and improving the herd.

In red-polled Ostland cattle of the Norwegian Agricultural College, free from contagious abortion and tuberculosis, only 50.5 per cent of the animals that had calved bore as many as five calves (Berge, 1942). Cows stay in Danish herds for approximately seven lactations. In the United States, cows are milked on the average not more than five years, i.e. an annual replacement of 20 per cent. The average milk-producing life of a Michigan D.H.I.A. cow, if all factors are included, is about 3.7 to 4 years (Cannon and Hansen, 1939). The data indicate that a dairyman must plan to reproduce his herd promptly because at 3.7-years lifetime expectancy of usefulness, only 1.85 years are probable as a source of supply for each heifer and bull calf. Since the heifers are the source of supply for future milk cows, the margin for replacement is comparatively narrow, especially if the calving interval is more than 12 months, and if only a low calf loss of 10 per cent is experienced annually. In Florida, the average productive life of dairy cows, from entering the herd until death or disposal, was 4.7 years for herds breeding their own replacements and 3.9 years for herds buying replacements (Becker *et al.* 1954).

The British Friesian Cattle Society reported that the average working life of 3,000 British Friesian cows yielding over 2,000 gallons was about seven years. From a study of 75,000 pedigree and non-pedigree lactations in National Milk Records (1948), the average number of times calved was 3.1; only 20 per cent had five and more lactations. From a sample of 78 herds of widely varying size and production, Phillips (1949) found the average milking herd life was 3.8 years. Small herds of less than ten cows retained their animals for only 3.2 years in milk; for herds of over 20, the figure was five years. Herds with yields below 500 gallons kept their animals for four years; herds with 700-gallon averages and above, only 3.5 years. Dinsdale and Winter (1955), in a North of England investigation, noted that only a fraction over 16 cows in every 100 were in their fifth or higher lactation.

Causes of Wastage in Cows

The main classifications of wastage in different countries have been listed in Table I, with the percentage of each type, based on the number of disposals, less the number of cows removed from herds in the ordinary course of business. The incidence of each type varies considerably, since the criteria for classification are not absolute. There may be difficulty in giving precise age to cows, and age and accidents are not always listed separately. The term "miscellaneous" may cover known and unknown causes; and standards for milk yield vary in different circumstances. Some surveys, such as those in Queensland (Pegg and Rice, 1949; Clark and Paul, 1953), gave a very detailed classification, including such things as poisoning, bloat and drought. Withers (1955) reported the results of a pilot survey in England, based on random samples of herds, aiming at standardizing disposal categories and disease groups. Data were given for size of herd and age distribution of cows in herds, deaths and their causes, and the incidence of total sickness, divided into conditions associated with parturition and other disease conditions. Categories for aged, infertile and poor milk yield tended to overlap, as many animals were culled for more than one reason and it was often a matter for personal judgment to which category a given animal was allotted. Taken together, these categories comprised about 11 per cent of the total cows or an overall 46 per cent of total disposals.

Among 2,182 cows, mastitis, low production, reproductive trouble and death accounted respectively for 21.3, 18.8, 12.7 and 14.2 per cent of disposals (Becker *et al*, 1954).

In most countries, sterility is responsible for a high proportion of the disposals. In Sweden, Berge (1942) noted that infertility, the important cause of culling (37.6 per cent), greatly hindered selection for milk yield. In Britain, sterility is responsible for 6.1 per cent and 4.5 per cent (Cmd. 1934; Withers, 1955) and in America for 3.8 per cent (Baltzer, 1940) of the total number of cows, less disposals for surplus.

Currie (1939) examined the economic significance of contagious abortion. Loss of calves, depreciation, including deaths and loss of milk yield represented only the immediate cost and did not include any part of the ultimate expenses such as the disruption of the breeding policy in a self-contained herd. In one herd, 40 per cent of the aborting animals became sterile and others were slow breeders. Reduction in milk yield in the lactation following abortion was the greatest direct loss.

Loss of calves due to contagious abortion was 5.5 per cent for England and Wales, prior to the introduction of S.9 vaccine (Lovell and Hill, 1940) and 2.5 per cent after its introduction in 1950–52 (Withers, 1955).

The percentage of deaths for total cows, less surplus, was 1.3 per cent in America (Baltzer, 1940) and 1.4 per cent in England (Withers, 1955). In Wales, the figure was 2.3 per cent (Williams, 1943; Pryce-Howell, 1945). In Zebu herds in Kenya, deaths accounted for 3.5 per cent of the total number of cows.

Phillips (1949) remarked that short productive life of dairy cows was due in large measure to high incidence of disease which, in turn, probably came from faulty nutrition or bad management. Loss from disease in milk and calf production is roughly calculable; loss caused by need for rearing otherwise unnecessary replacements of more doubtful milking capacity is incalculable.

Genetic constitution has been found to influence longevity in a Holstein-Friesian herd (Wilcox and Pfau, 1955).

Zebu Cattle

Disposals of Zebu female stock from African training centres for the years 1939 to 1942 were investigated. Of a total of 1,825 cows, 349 (19.1 per cent) were disposed of, and 208 (11.4 per cent) of these, mostly for poor milk yield, which was 60 per cent of the total disposals. Withers's figure of disposal of surplus stock and poor yielders was 41.2 per cent.

The percentage of disposals for accidents, old age, deaths, sterility, udder trouble and miscellaneous causes was 2.1, 16.3, 45.4, 3.5, 0.7 and 31.9 per cent.

The percentage of disposals for Zebu cows is very similar to that for cows in other countries (Table I), though the incidence of causes is different.

Age of Cows

A dairy cow reaches her maximum production of milk about the 8th year of life and yield does not decline greatly until the 12th year (Sanders, 1928; Kay and M'Candlish, 1929). For Ayrshire cows, the best age at calving is 2½ years (M'Candlish, 1928). Smith and Robinson (1931) stated that if the productive life of a cow lasts ten years (2½–12½ years), the average age of the cows should be 7½ years; and since at any age there should be found 10 per cent of cows in the herd, the annual replacement number should be 10 per cent.

The age distribution of cows has been used for studying wastage. Smith and Robinson (1931) found the average age at calving to be 5.722 ±0.04 (s=2.816); in four pedigree dairy breeds, the average age was 5.485 ±0.05 (s=2.578) and in three pedigree beef breeds 6.002 ±0.05 (s=2.676). 2.4 per cent of cows calved at over 12 years, ten (0.38 per cent) at 14 years and one at 15 years.

If heifers calve for the first time at 2½ years, the length of the productive life of the dairy cow is 5.485, less 2.5 years, which makes 2.98 years; allowing six months as the average length of productive life of a cow in a pedigree herd after her final calving, gives a figure of 3.48 years as the average herd length of total productive life, which means that there is an

Table I—Classification of Wastage

	Britain				U.S.A.	Australia	N.Zealand†
	Cmd. 1934	MacGregor et al. 1941	Phillips 1949	Withers 1955	Baltzer 1940	1947–1952	
No. of cows	78,905	1,945	—	8,418	105,258	—	—
No. of disposals	17,247	620	—	2,034	25,449	—	—
Per cent of disposals	21·9	31·8	26·0	24·2	24·1	24·2	16·8
Per cent of disposals, less surplus	17·8	22·4	—	19·0	19·0	17·4	—
Disposals (less surplus)	21·6						
Poor milk yield	21·6	6·2	11·0	25·0	52·0	30·1	34·5
Accident	1·8	3·7	3·5	—	—	5·4	3·4
Aged	5·3	3·2	—	11·3	3·0	20·1	—
Miscellaneous	—	—	19·5	—	7·0	18·2	11·8
Failure to breed	32·8	32·6	33·6	22·3	20·0	8·1	15·8
Udder trouble	9·4	6·7	16·8	—	11·0	10·6	22·9
Disease	29·0	22·0	15·5	41·3*	6·0	7·5	11·4

*Disease and accidents —34·2 per cent; deaths, 7·1 per cent.

†Cited by Phillips.

annual replacement requirement of about 29 per cent in the breed studied. Wright (1933) worked out the average calving age of over 7,000 milk-recorded animals at 5.6 years. Only 25 per cent calved at over this age. When the age at first calving (2.8 years) was taken into account, the average milking life, allowing 10 months for the final lactation, was 3.6 years. Only a relatively small proportion of pedigree- and milk-recorded cows lived beyond the age of seven years. Pettit (1940) from the age distribution of 3,875 milk-recorded cows found that the average length of productive life was probably a little more than four years, and that the average length of total productive life in all herds was probably a little longer.

Pettit stated that Smith and Robinson and Wright appeared to assume that in their samples, actual average age was the same as average total length of life, an assumption which is difficult to justify, if the picture for a marked tendency for wastage to be greater in the higher age groups is even approximately correct and believed that calculations based on wastage will probably over-estimate the average length of total productive life, while calculations based on age distributions will underestimate it.

Average Age of Cows in Kenya

The average age of sires and dams of calves of two pedigree breeds was obtained from the East African Studbook and for the Zebu cows for the same year from the African Veterinary Training Centres (Table II).

TABLE II

Breed	No. of Calves	Age of Dams	Age of Sires
Ayrshire ..	173	5·57 ± 0·195 (s=2·57)	4·26 ± 0·155 (s=2·04)
Friesian ..	141	5·72 ± 0·195 (s=2·32)	5·18 ± 9·131 (s=1·56)
Zebu ..	238	5·75 ± 0·150 (s=2·46)	6·86 ± 0·108 (s=2·70)

12.4 per cent of the pedigree cows calved at three years and under and 6.3 per cent of the Zebus.

Smith and Robinson's calculation gave the average length of total productive life of Ayrshires and Friesians as 3.65 years, i.e. an annual replacement of 27 per cent.

As in Britain, this figure for productive life is probably an underestimate. It seems that the average productive life of pedigree cows in Kenya and the annual replacement percentage are very similar to that in Britain.

The average age of calving for Zebus was about 40 months, which gave an average length of total productive life as 2.95 years, i.e. an annual replacement of 33.9 per cent. The low productive life of Zebus and the high annual replacement percentage is probably related to the fact that the herds were in the process of being built up and had many disposals of poor yielding cows.

However, the percentage of disposals (19.0) for Zebu cows, calculated from wastage, was considerably less than that obtained from age distribution (33.9) and likewise, the average productive life was higher (5.5 years) for the former than for the latter (3.0 years). As Pettit said, the former probably over-estimates this period the latter underestimates it.

AGE OF BULLS

Smith and Robinson (1931) gave the average age of bulls at the time their progeny was born as 3.687 ±0.03 (s=1.763) for dairy bulls and 4.052 ±0.04 (s=2.09) for beef breeds. 1.2 per cent of sires of dairy calves was over nine years and the oldest bull was 15 years. Since many bulls are dead by the time their progeny are born, Smith and Robinson deducted nine months, the time of conception of the progeny, thus giving the average age of dairy bulls as 2.9 years. Taking the age of bulls when first used as 15 months, the average productive life of a dairy bull was 1.65 years, which gave an annual replacement percentage of about 60 per cent. Smith and Robinson stated that in dairy breeds over 80 per cent of bulls were disposed of before their genetic value could be recognized.

The average age of bulls in Kenya, particularly Zebus, is rather higher than that in Britain given by Smith and Robinson.

Becker and Arnold (1940) gave the average useful life-span of good proved bulls of four dairy breeds as: Ayrshire, 11.19 ±2.75 years; Guernseys, 10.45 ±2.58 years; Holsteins, 10.77 ±2.66 years; Jerseys 11.07 ±2.56 years.

Becker and Arnold (1950) ascertained how long bulls were retained in A.I. societies. Out of 41 bulls, 32 were 6½–9½ years old when first used. The average period for which all the bulls were used was three years (0.17–8.39 years). In a further study (1953) on the tenure and turnover of desirable dairy bulls in artificial studs, of 189 bulls, 26 started artificial service between two and 5.9 years of age; 121 others at six to 9.9 years, and 42 at ten to 15 years. These 189 desirable bulls were in artificial service for an average of 2.68 years, ranging from 14 days (died) to 10.75 years. 29 per cent of these bulls lasted less than one year; 47 per cent were used for one to 4.9 years and 6 per cent from seven to 10.75 years.

In Sweden, bulls belonging to bull associations are, as a rule, discarded at four to 5½ years.

Causes of Disposal of Bulls

There are many different causes for disposal of bulls and they vary under different conditions. In general, the reasons for disposal include reluctance to mate bulls to own daughters, old age, viciousness, bulls not kept according to the rules of good husbandry, incidental disease and various types of infertility and sterility.

Lagerlof (1934) from an examination of the records of Swedish Bull Associations found that 2,313 bulls were culled for the following reasons: fear of inbreeding, 38.7 per cent; sterility 23.6 per cent, disease other than sterility 13.7 per cent, heaviness or viciousness 11.2 per cent, and cause unknown 12.8 per cent. Sterility is a common cause of disposal in Denmark and in Sweden (Anderson, 1939). Scott (1949) for New South Wales gave the causes as 25 per cent inbreeding, 12.5 per cent age and 2.8 per cent sterility, compared with 15.8, 9.8 and 9.3 per cent respectively for New Zealand. Ward (1940) stated that 3 per cent of all bulls in use in New Zealand were culled each season for sterility. Kahnert (1942) gave the causes of wastage of 1,000 bulls from the German Farmers' Service as: disease 75.1 per cent, sterility 23.5 per cent and viciousness 1.4 per cent. Bauer (1956) for Germany, attributed 14.2 per cent to sterility.

Becker and Arnold (1940) noted that the causes of losses among 1,097 bulls of four breeds of all ages were: sterility 27.6 per cent, died of unknown causes 23.3 per cent, old age 10.3 per cent, accidents 6.8 per cent, foreign bodies 5.4 per cent, lameness 4.4 per cent, infectious diseases 12.8 per cent. Of 248 bulls used for artificial insemination, all of which were discarded for one reason or another, 56.4 per cent were discarded for lowered fertility, 7.3 per cent for complete sterility, and 4.4 per cent for accidents; the remainder suffered from disease or some other abnormal conditions (Becker and Arnold, 1950). Of 189 desirable bulls in artificial service, selection, good management, and veterinary care held the proportion of losses from infectious diseases to about one-half that observed with over 4,000 bulls in natural service. Of the 189 bulls, 25 died, 157 were salvaged for beef and seven were disposed of (no reason stated) at advanced age. Thirty-eight per cent were slaughtered for low breeding efficiency (Becker and Arnold, 1953).

Becker and colleagues (1954) found that of 2,254 bulls discarded while fertile, 34.5 per cent were to avoid inbreeding, 14.1 per cent for bad disposition and 10.4 per cent for low production of daughters. Of 5,177 bulls whose natural services were terminated by non-infectious and infectious causes, over 25 per cent became sterile; low fertility and inability to serve accounted for 8.8 per cent; old age nearly 8.8. per cent; accidents and injuries took 10 per cent; and causes of death of 11 per cent were not reported.

Summary

Wastage, replacement, the average age of dams and sires and the length of productive life of dairy cows and bulls are reviewed. The average age and the length of productive life of pedigree cows in Kenya are very similar to that in Britain. The average productive life of Zebu cows, calculated from age distribution, is less than that of pedigree cows. The percentage wastage in Zebu cows was similar to that in other countries, although the incidence of causes was different. The average age of pedigree sires in Kenya was greater than in Britain.

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LETTER TO THE EDITOR

FERTILIZER MIXTURE

Dear Sir,—We have read with much interest the paper by Dr. J. B. D. Robinson on "The Influence of Fertilizers and Manure on the pH Reaction of a Coffee Soil" (published in your October, 1956, issue) in which it is shown that on Kikuyu red loams the regular use of sulphate of ammonia substantially increases the acidity of the topsoil and may have injurious indirect effects on the nutrition of the coffee tree, in particular, in connexion with the availability of phosphorus.

As one means of overcoming this problem, Dr. Robinson recommends the use of a mixture of nitrogenous fertilizers that will have little or no influence on the soil reaction. He mentions, specifically, a mixture of approximately 75 parts ammonium sulphate and 25 parts sodium nitrate and gives as a reference W. H. Pierre's "Nitrogenous fertilizers and soil acidity. II. The use of fertilizer combinations, lime and basic slag, in correcting the acidity formed by various nitrogenous fertilizers" (Journal of the American Society of Agronomy, Vol. 20, No. 3, of March, 1928).

We should be much obliged if you would publish this letter in order that coffee growers among your readers may be made aware that the figures for the proportions in which the two fertilizers should be mixed appear, unfortunately, to have become inadvertently transposed.

The mixture actually recommended by Pierre for a neutral nitrogenous fertilizer is one in which 75 per cent of the nitrogen comes from nitrate of soda and 25 per cent from sulphate of ammonia.

Yours faithfully,

NITRATE CORP. OF CHILE LTD.

Chile House,
20–24, *Ropemaker Street,*
London, E.C.2.

1st March, 1957.

[*Mr. Robinson is grateful to the Nitrate Corporation of Chile Limited for drawing attention to this error which was caused by an inadvertent transposition in the original typescript of this paper.* (*Ed.*)]

RELEASE OF NEW CEREAL VARIETIES—1957

By H. C. Thorpe and G. E. Dixon, Plant Breeding Station, Njoro, Kenya

(*Received for publication on 31st January, 1957*)

The undermentioned cereals have been released by the Department of Agriculture for sowing during the 1957/58 season. In conformity with established procedure the varieties have been tested in trial plots on the Plant Breeding Station and district stations, and subsequently with farmers in various parts of the country.

The varieties marked with an asterisk are available as pedigree seed under the new Pedigree Seed Scheme.

WHEAT

Wheats 358.*AC*.4.*A*, 358.*P*.7.*C** *and* 358.*R*.7.*E**

Three further strains from the cross 184.P.2.A.1.E × 294.B.2.A.3 developed at Njoro; and sisters to 358AA.5.B released last season.

Both 358.AC.4.A and 358.R.7.E are bearded, but the P.7.C selection is beardless. The first is white-grained and the others are red. All are white-chaffed, of moderate straw strength and mid-season maturity, though 358.P.7.C tends to be rather later than the other varieties.

These varieties have done well at Njoro, Thomson's Falls, Ol Kalou and Moiben, but cannot be considered fully resistant to stem rust. In particular they did suffer some damage by stem rust in the Trans Nzoia this past season.

As with the earlier release 358.AA.5.B, they are suited to areas from 6,500–8,000 ft., but above this altitude may suffer damage from yellow ear rust. It should be noted, however, that 358.AC.4.A tends to shed when dry and should be harvested as early as possible.

These varieties are not necessarily superior to 358.AA.5.B, but are being released since they offer alternatives at a time when the choice of varieties is limited.

Wheat 363.*K*.1.*B*.3

A selection from the cross Warigo × 261.S.10.C.2.D made at Njoro in 1945.

This is a bearded, white-chaffed, white-grained variety of mid-season maturity and fair straw strength.

It has done reasonably well on a field scale at Eldoret, Thomson's Falls and the Kinangop. In the Trans Nzoia it was attacked by stem rust, in common with all varieties this past season, but in the high country it has remained free from stem rust. It is suited to areas from 7,000–8,000 ft. but above the latter figure it is not advised owing to the danger of damage by yellow ear rust.

It is considered that 363 may prove a useful variety in spite of its stem rust susceptibility and therefore it has been decided to proceed with its release. This wheat likes fertile conditions for best results.

Wheats 362.*B*.1.*A*.1.*B and* 362.*B*.1.*D*.3.*D*

Two further selections from the cross Equator × 294.M.7.C.6.C developed at Molo; and sister strains to the variety 362.B.1.E.4 released in 1956.

They are beardless, red-grained varieties. Selection B.1.A.1.B is white-chaffed, of mid-season maturity and moderately short straw; B.1.D.3.D is a red-chaffed, late season variety of taller and rather weaker straw.

As was the case with 362.B.1.E.4, these varieties have shown some susceptibility to stem rust during multiplication. However, since they are high-altitude wheats it is hoped that this will not prove a serious drawback. Both varieties show resistance to yellow ear rust even at the highest altitudes and are suited to areas above 8,000 ft.

The B.1.D.3.D selection is of particular interest since it is a late variety with better stem rust resistance than Equator, and it may therefore replace this variety at the highest altitudes.

Wheats 1066/1 *and* 1066/6

Single plant selections from the established parent variety.

They are bearded and posssess the same general habit as the parent though the straw is somewhat stronger. Both have done well on a field scale and are slightly higher yielding than the parent. The heads droop at maturity and possess the ability when ripe to withstand rain without sprouting. Both selections are suitable for areas in which 1066 itself is grown and are approximately of the same maturity.

Mida Cadet Wheat

A direct importation from Canada. Mida Cadet is a beardless, white-chaffed, red-grained wheat of mid-season maturity and good straw strength. Seedling tests show it to be resistant to earlier races of stem rust, but tests to the later forms have still to be carried out.

Mida Cadet has done reasonably well at Njoro and Rongai but is somewhat susceptible to glume blotch and suffered from attack this season. It has been slightly attacked by stem rust in the field but not damaged. It is suited to areas from 6,000–7,000 ft. but it is not recommended for higher altitudes owing to susceptibility to yellow ear rust.

Mida Cadet is very similar in appearance to Regent, another Canadian variety. It possesses small, hard, red grain of good baking quality. Owing to its susceptibility to glume blotch it is likely that a dry year will suit it best.

Capella Wheat

A durum or macaroni wheat privately imported from Italy and multiplied in co-operation with the Department. Capella is a bearded, white-chaffed variety of mid-season maturity. It possesses tall weak straw and hard, amber-coloured grain.

Capella has done well on a field scale at Upper Gilgil, Ol Kalou, Ol Joro Orok and Thomson's Falls. It has been slightly attacked by stem rust both in 1955 and 1956, but not appreciably damaged. It is suited to areas from 7,000–8,000 ft.; above this altitude it is not advised owing to the danger of yellow ear rust damage. Due to weak straw it is liable to lodge if sown on very rich land.

Hopeful and Impala Wheats

The opportunity is taken to make known two wheats imported by an Eldoret farmer from South Africa in 1951. Since they are a private importation, no release procedure is involved in this case. Both are bearded, white-chaffed varieties of mid-season maturity with straw of fair standing ability. Hopeful has white and Impala red grain.

Both varieties have done fairly well on a field scale in the Eldoret and neighbouring areas. Although the Department claims no credit for their introduction and subsequent increase, both varieties have been under observation since they were introduced and may now be recommended for general planting. Hopeful is the more aggressive variety and higher yielder.

They are suited to areas from 6,000–7,500 ft. but not higher owing to the danger of damage from yellow ear rust.

BARLEY

*Barley No. 5**

A selection from the cross Kenia × Spratt Archer, imported from Eire. No. 5 is a two-row, mid-season barley of high yield and straw strength. It combines the short and stiff straw of the Scandinavian parent with the larger grain of the Archer barley.

The variety has done well at Njoro, Timboroa, Nakuru, Upper Gilgil and Mau Summit. It is suited to areas from 6,500–9,000 ft. It is potentially a high yielder and has given good samples of mealy grain. It is not yet known whether the variety will be acceptable to the breweries for malting; this must await the results of larger-scale plantings. Better yields and quality are likely to be obtained in the higher areas.

*Heimdal Barley**

A Scandinavian barley from the cross Peragis × Maja, imported from Sweden. Heimdal is a two-row, mid-season variety selected for heavy yield and strong straw. The variety has done well at Njoro, Timboroa and Ol Joro Orok, and is suited to areas from 7,000–9,000 ft.

Heimdal is an exceptionally aggressive barley and has exceeded all other varieties in trials at Njoro: it has kept up this performance on a field scale when conditions have been sufficiently moist. In Swedish trials it has shown a strong straw, moderately high bushel weight, and a low protein percentage.

It has been approved by Stockholm breweries as suitable for malting but, as is the case with No. 5, it is not yet known whether Heimdal as grown in Kenya will be acceptable to the local breweries.

OATS

Oat 3003.*F*

A direct importation from Canada. Oat 3003.F is an aggressive oat of fair bushel weight, mid-season maturity and fair straw strength. It has yielded well at Njoro, Ol Joro Orok and Thomson's Falls, is suited to areas in Kenya from 8,000–9,000 ft. and should be useful as a dual-purpose variety. It has done particularly well on soils stated to be too poor for pyrethrum and which gave only small crops of Lampton. The variety has been strongly attacked by stem rust at 7,000 ft. and for that reason should be kept to the higher altitudes. It is not yet known whether the grain will be acceptable to the mills for porridge.

MAIZE

Synthetic Maize

The first synthetic maize completed its multiplication this season and is now released. The production of synthetic maize was described in the *K.I.O. Fortnightly*, No. 413, of 1st July, 1956 (4186). Briefly, it is a mixture of high-yielding lines which have been inbred for one or two generations. Reports show that, generally, it has yielded slightly better than ordinary farm maize due chiefly to the elimination of barren plants.

This synthetic was derived from Njoro maize and although it has done well in other areas it is nevertheless recommended that in general it be grown at about 7,000–8,000 ft. where conditions allow a long season.

Farmers are advised to buy seed in their own district wherever possible and should note that it will still be necessary to select seed annually in the usual manner to keep up the standard of the variety and prevent deterioration.

NOTE:—

Stem Rust of Wheat = *Puccinia graminis tritici.*

Yellow Rust of Wheat = *Puccinia glumarum tritici.*

Glume Blotch of Wheat = *Septoria nodorum.*

Stem Rust of Oats = *Puccinia graminis avenæ.*

REVIEW

MILK AND BUTTERFAT RECORDING: A WORLD SURVEY, by E. D. Ashton. Technical Communication No. 3 of the Commonwealth Bureau of Dairy Science and Technology. Published by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England. Price Sh. 30 net.

The economic value of a dairy cow can only be estimated by knowing the regularity with which she breeds and the quantity and quality of milk she produces in each lactation. A proportion of the world's dairy cows are so recorded, but the systems adopted vary considerably from one country to another and the methods of interpreting the results are by no means uniform.

For a long time there has been a need for a book which surveys these different systems. Now, Mr. E. D. Ashton, head of the Bureau of Records in the Production Division of the Milk Marketing Board of England and Wales, has collected together the available information on milk recording and butterfat testing in the world and presents these facts in an authoritative and comprehensive survey of the whole subject.

The book is divided into two main parts, the first dealing with the historical development of the milk recording movement, how it is organized and financed, what recording entails in practice, how the records are used by farmers, breeders, A.I. movements, research workers and others, and what international efforts are being made to further milk recording aims. The second and larger part surveys the milk recording systems used in all the countries throughout the world from which information is available.

A large number of tables and figures illustrate the text. In these tables and in the appendices are statistics relating to the national dairy herds of different countries, the proportion of recorded cows, yields of milk and percentages of butterfat, etc.

The book is well printed, bound in a grey cloth over stiff boards and has an attractive dust jacket. It measures 9¾ in. × 7¼ in. (24.5 cm. × 18.5 cm.) and contains 215 pages, 43 plates and figures, 92 tables and nearly 200 references,

IRRIGATION EXPERIMENTS AT THE COFFEE RESEARCH STATION, RUIRU, KENYA

By **P. A. Jones and J. A. N. Wallis, Department of Agriculture, Kenya**

(Received for publication on 20th November, 1956)

Irrigation practice in coffee was reviewed by the staff of this Research Station towards the end of 1954 [1]. At the same time every aspect for investigation was considered and the proposed experimental programme was tabled for discussion by the Standing Coffee Research Advisory Committee. It was agreed that the basic problems in need of study, which could be incorporated in any long-term trials, were as follows:—

1. The timing and frequency of irrigation.
2. The method of placement and quantity of water (related to the distribution over and in the soil).
3. The effect of mulching in relation to irrigation.
4. The addition of farmyard manure and minerals.

Furthermore it was concluded that in any irrigation trials these problems should be assessed by their relation to vegetative growth, flowering, crop yield, pests and diseases and the fluctuation of soil moisture and nutrients.

In the East Rift district especially, the influence of soil moisture on the coffee tree is so profound that much of the knowledge acquired under a pattern of natural rainfall is questionable when the pattern is radically altered by irrigation. Hence a wide field of new problems is opened to investigation wherein the experimental technique required to control normal variation has to be carefully considered if fundamental questions are to be answered conclusively. In this instance, owing to the restrictions imposed by the size of the trial area available, only the first two problems cited above could be included in the main trial, adequate replication being preferred to a wide scope of treatments.

In order to gain knowledge of the best methods and technique of applying water accurately to small plots a preliminary trial was undertaken during 1955. The experience so acquired proved invaluable in planning the equipment and layout to be adopted in the long-term trial, a description of which follows.

DESIGN AND TREATMENTS

The main trial which began in May, 1956, is designed as a 2 × 2 × 2 factorial in three replications with split plots, to test the following treatments on mature multiple-stem coffee:—

Method of Irrigation:—

(*o*) Overhead sprinkler irrigation.

(*g*) Ground watering by pipeline to 4 ft. × 4 ft. bunded ponds under the trees.

Time of application:—

(*a*) End of Short Rains (December).

(*b*) End of Long Rains (May/June).

(*c*) Spot application in August.

(1) No irrigation.

By factorial combination of the two levels (+ or −) of (*a*), (*b*) and (*c*) the eight separate treatment combinations become (1), a, b, c, $a + b$, $a + c$, $b + c$ and $a + b + c$. These treatments are applied to main plots, each of which is split for direct comparison of the two methods of application. Thus in three absolute replications the trial contains 24 main plots or 48 sub-plots. By splitting the plots the comparison between the two methods of applying water is highly replicated and consequently relatively small differences in crop response may be detectable. The quantities of water to be applied are determined according to the principles described by Dr. Pereira elsewhere in this *Journal*.

Six extra sub-plots are available within the trial area; water will be applied to these monthly to maintain soil moisture within the root range of the tree at an optimum level throughout the year. The contrast between the two methods of application will be retained by split plots similar to those in the main trial and the amount of water to be added will be calculated monthly according to the apparent loss during the month due to evaporation and transpiration. The extremes of no irrigation and fully available soil moisture throughout the year can thus be contrasted and the results compared with those of parallel treatments in the Growth Recording Trial operated by the Plant Physiologist, Mr. R. W. Rayner, wherein other treatments are combined in a factorial arrangement to allow a precise study of the influence of environment on the growth, bearing habit and physiology of the tree.

A standard mulch is laid across all plots in March, in six-foot bands between alternate rows of trees, each inter-row being mulched every two years. The effect of added nitrogen will be tested from 1957 onwards; by using the "half replicate" device of confounding described by the late Dr. E. M. Crowther [2] the response to an annual dressing of 100 lb. per acre of urea may be evaluated without increasing the number of plots.

Field Layout and Equipment

The trial area is set in one rectangular block of unshaded mature coffee, at a spacing of 10 ft. × 10 ft. Each main plot contains two rows of 21 trees, the centre pair of trees separating transversely the two subplots. All treated trees are pruned on the multiple stem system, with every plot surrounded by a single guard-row of single stem trees.

It is essential that the introduction of irrigation should not entail a return to hand-weeding. The method of mulching and the size of the bunded ponds are such that weeding can be carried out using a tractor and modified "Rotavator" in one direction whenever required or in both directions as the mulch ceases to be effective towards the end of the year.

A three-inch water main was laid across the ends of the plots with a stand pipe and quick-coupling globe-valve to serve every three main plots.

The necessary water pressure is provided by a centrifugal pump driven by a 3.5 horse-power diesel engine. These are both placed on a hand trolley with pneumatic tyres so that the power unit may be wheeled into the field whenever it is required. The water supply is drawn from a tank about 20 ft. above the booster pump already mentioned.

In order to apply water accurately to rectangular plots of coffee it was necessary to modify standard irrigation equipment. "Perf-o-Rain" aluminium equipment was chosen for the overhead irrigation as it appeared accurate, easy to assemble and very light. Specially adapted aluminium piping was also used for the ground watering and is described in a later paragraph. Each set of equipment includes a pressure gauge and water meter mounted on a light frame, so that the rate and amount of water applied is carefully regulated and accurately measured.

The Kikuyu Red Loam soil on which the trial is situated has been shown by Pereira [3] to have a very high rate of water infiltration; consequently it was considered safe to irrigate at a rate of up to two inches per hour. In this way it was hoped to take not more than one week to apply the required irrigation at each of the three seasons.

Overhead Application.—The "Perf-o-Rain" equipment consists of two-inch aluminium piping pierced on one side with a pattern of small holes which, when directed upwards, produces an even spray of fine water droplets. The pipes are supported six feet from the ground on bipods spaced at 20 feet intervals. To confine the spread of the irrigation the holes directed at 45° from the vertical were sealed and the pattern of the remaining holes was repeated in order to increase the rate of irrigation. When working at a pressure of 22–25 p.s.i. the system now applies water at the rate of 1.3 inches per hour and ten inches of irrigation has been applied in eight hours without any apparent detriment to the soil.

Ground Application.—A nozzle was fitted on each side of the ball couplings on 10-foot lengths of 1½-inch aluminium piping and a brass disc drilled with a 3/32 in. hole was placed inside each junction. When the water in the main pipe was at 30 p.s.i. a fine regular jet of water resulted which could be conveyed through a short length of plastic hose to the base of a tree surrounded by a 4 ft. × 4 ft. bund. In this way it has been possible to ensure that irregularities in level within a plot do not cause any appreciable variation in the amount of water each tree receives. At 30–32 p.s.i. it has not been possible to apply more than one inch per hour, but this has not delayed the irrigation because the volume of water to be given by the ground system is only half of that applied by the overhead sprinkling.

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THE SEASONAL ASSESSMENT OF WATER NEEDS IN THE IRRIGATION OF COFFEE

By H. C. Pereira, East African Agriculture and Forestry Research Organization

(*Received for publication on 22nd November, 1956*)

In the areas of unshaded Kenya coffee east of the Rift, planters realize very keenly how dependent are their crop yields upon the vagaries of rainfall. Every coffee planter can do a certain amount to help himself out of these difficulties. The Coffee Research Station at Ruiru, Kenya, has shown what substantial increases in yield can be obtained by securing full penetration of rainfall and its subsequent protection by the use of grass mulches, and this practice is being widely followed. Improved weeding efficiency with implements specially devised to leave a rough cloddy surface which can effectively absorb rainfall, has been shown at the Coffee Research Station to be another profitable way of securing a better share of the rainfall for the coffee (Pereira and Jones, 1954); the encouraging results reported by Robinson (1956) suggest that the supplementing of cultivation by weed-killing sprays may soon become routine practice. The third method of assistance to the coffee is the most direct but the most expensive, that of supplementary irrigation. This has been pioneered by enterprising planters, encouraged by the high coffee prices of recent years, and striking responses have been obtained from water applications.

Irrigation of Kenya coffee raises difficult questions both for the planter and for the water resources authorities. The fair allocation of the rights to impound flood-water and to pump dry-weather stream-flow must involve a knowledge of how much water can usefully be employed per acre, and of the critical times of the year in which the application will produce the maximum extra crop. The planter also needs to know what are the most effective quantities to apply at any one time.

Assessment of Water Need

In the course of studies on the soil moisture changes under coffee trees as affected by mulching and other cultural practices at the Coffee Research Station, Ruiru, and also of subsequent studies of soil moisture, evaporation and weather relationships by the Physics Division of E.A.A.F.R.O., there has now accrued a sufficient body of evidence on which to base a practical method of estimation of coffee irrigation requirements. These calculations are the basis for the water applications in the irrigation experiments described by Jones and Wallis elsewhere in this issue. The method is described here in the hope that they may be of assistance to estates on which irrigation is already in progress.

Many years of research in England by Dr. Penman, of the Physics Department at Rothamsted Experimental Station, and also parallel lines of research by Dr. Blaney, Dr. Thornthwaite and other scientists in the U.S.A., have shown that when a continuous cover of the foliage of temperate-zone crops is freely supplied with soil moisture, the total rate of water loss by evaporation and transpiration depends directly on weather factors, and may be related to the rate of evaporation from open water.

While the measurement of evaporation from open water is itself a complex subject, a useful approximation can be obtained from a conventional evaporation tank, particularly if this is insulated from heat gains or losses through the base and sides.

The writer installed four evaporation tanks, together with the necessary meteorological instruments, at the Coffee Research Station, Ruiru, in 1950. One of these was under multi-stem coffee to estimate the water losses from weeds and soil partially shaded by the coffee foliage. The other three were contrasting exposures of 4-ft. diameter circular tanks. Two of these tanks have subsequently been maintained continuously in operation by the staff of the Coffee Research Station. The whole set have given useful comparisons with measured soil moisture changes and with estimates of evaporation from weather data.

The canopy of unshaded multistem coffee does not provide a complete soil cover, so that some of the incoming energy from sunlight strikes mulch, weeds, or bare soil. The coffee foliage is fully supplied with soil moisture for only part of the year and, when drawing water from a partly dry soil, the rate of water loss falls off rapidly as the soil dries out. The relation of the open water evaporation to the water use of coffee therefore varies substantially from month to month, Taking all these factors into account, it has been possible to make an approximate estimate of the relation between the evaporation rates of open water, as measured by tanks, and the rate at which the coffee crop draws on the soil moisture supply. This affords a logical basis for controlling supplementary irrigation. The technical details have been submitted for publication as a formal scientific paper (Pereira, 1957).

Fig. 1 shows the variation in open water evaporation and rainfall over the past six years at Ruiru. Table 1 shows the approximate soil moisture deficit under coffee at the Coffee Research Station, Ruiru, as estimated in each month by the methods described above. These estimates show satisfactory agreement with the occasional soil samplings, taken in 1950/51 and 1955/56, i.e. before and after the Kenya Emergency's active phase.

The table is given in detail so that planters may compare it with their own records and experience. It is clear that the soil within the root range of coffee is not often fully recharged by seasonal rains at Ruiru, and that there is considerable scope for supplementary irrigation.

The relative merits of spreading the limited available irrigation water thinly over a large acreage, or concentrating it on a smaller area, are determined by two factors—

(*a*) the capital cost per acre of the distribution system and the labour costs of application;

(*b*) the crop response to differing quantities and patterns of water distribution.

Practical experience on (*a*) is rapidly developing in the industry, while the experiments at the Coffee Research Station are designed to

TABLE 1.—SOIL MOISTURE DEFICITS IN A PLANTATION OF ARABICA COFFEE

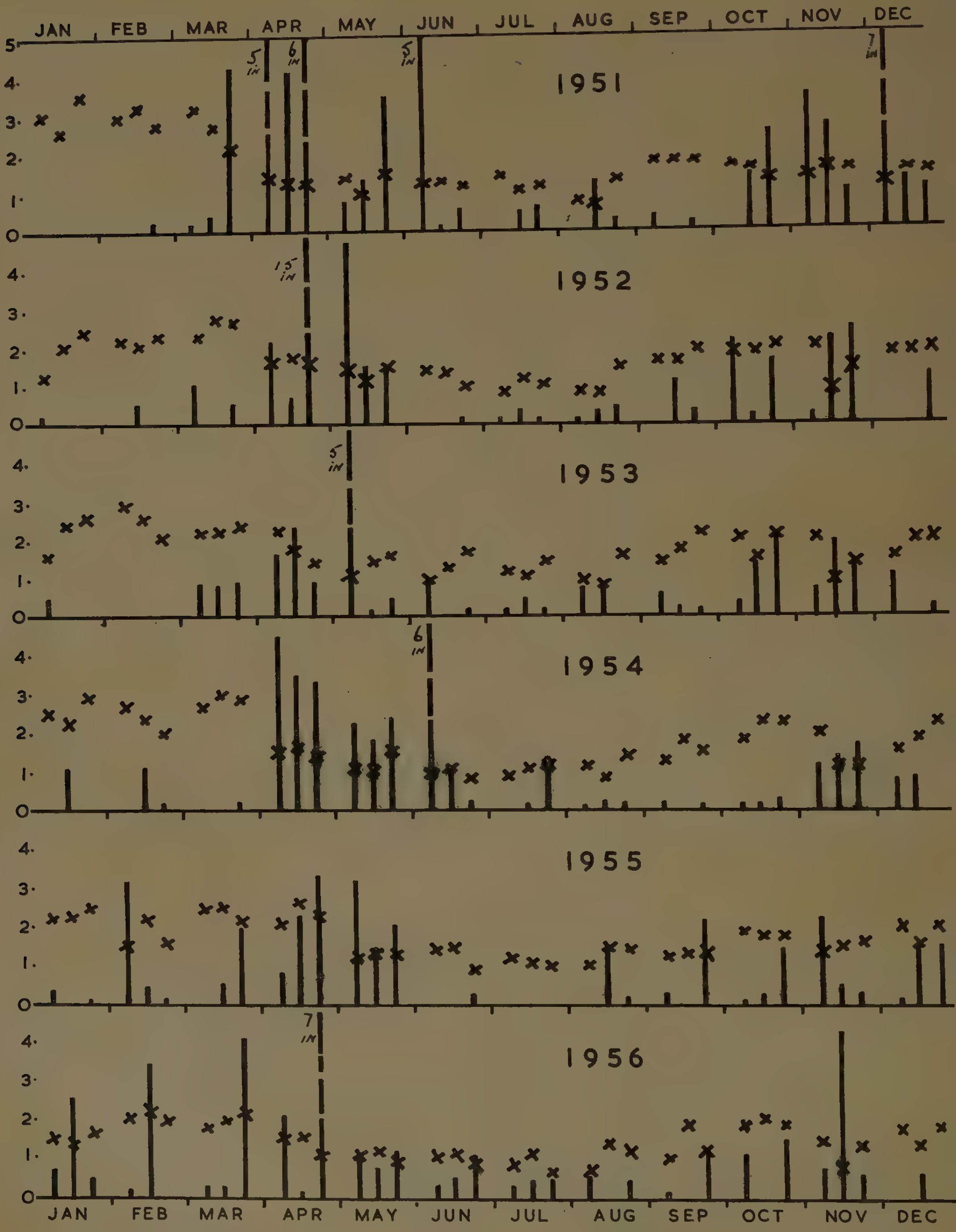
(*Monthly Summary of* 10-*day Calculations*)

The deficit is expressed as inches of water required to bring 10 feet of soil to "Field Capacity"

	1950		1951		1952	
	Rain	Deficit	Rain	Deficit	Rain	Deficit
January	1·43	—	Nil	12·60	0·15	2·96
February	0·13	—	0·31	12·90	0·58	5·73
March	5·41	—	4·68	10·51	1·60	8·02
April	8·99	—	16·18	Nil	17·95	Nil
May	2·67	2·00	5·51	Nil	8·69	Nil
June	0·25	3·00	6·17	1·12	0·15	2·45
July	0·42	4·81	1·24	2·29	0·53	4·03
August	1·85	5·45	1·56	2·39	0·84	5·08
September	0·31	7·76	0·70	4·39	1·31	6·38
October	0·54	11·53	3·84	3·14	2·94	6·09
November	3·04	12·00	7·20	Nil	4·85	4·51
December	0·34	12·30	8·79	Nil	1·15	6·68
TOTALS	25·38		56·18		40·74	

	1953		1954		1955		1956	
	Rain	Deficit	Rain	Deficit	Rain	Deficit	Rain	Deficit
January	0·53	9·48	1·09	12·25	0·44	11·47	3·90	9·92
February	Nil	12·10	1·26	12·55	3·84	10·75	3·50	10·28
March	2·53	12·40	0·12	12·85	2·46	11·31	4·83	9·22
April	5·00	11·66	11·42	4·95	6·41	9·75	8·98	3·72
May	6·11	8·86	6·44	1·48	5·68	7·29	3·20	3·26
June	1·13	10·55	6·79	0·52	0·30	9·58	0·88	4·67
July	0·85	12·00	1·54	1·30	0·02	11·90	0·54	6·22
August	1·54	12·00	0·58	2·75	1·76	12·00	1·01	7·33
September	0·93	12·30	0·24	4·83	2·47	11·44	1·33	8·21
October	3·73	10·79	0·54	7·54	1·70	11·73	2·62	8·51
November	4·24	9·80	4·40	6·59	3·14	11·94	5·58	5·53
December	1·26	12·00	1·69	8·42	3·16	11·10	0·61	8·05
TOTALS	27·85		36·11		31·38		36·98	

Fig. 1.—Ten-day totals of rainfall and of open water evaporation at the Coffee Research Station, Ruiru *(in inches)*



measure (*b*). In order to minimize evaporation losses and to economize in labour, a single overhead irrigation should not be less than 4 in. Where water scarcity overrules such considerations of efficiency, the minimum practical limit is about 2 in. overhead or 1 in. applied under the trees. The maximum application is often limited by the equipment available. In this soil type it is rarely limited by infiltration rates. Very large water shortages are known to occur, and deficits of 12 in. in the first 10 ft. of soil have been measured on many occasions by soil sampling under coffee at Ruiru (altitude 5,400 ft.) and at Kabete (5,800 ft.). Similar deficits have been measured under grass in the same soil type at both Muguga (6,800 ft.) and Tigoni (7,200 ft.) After free drainage has ceased, the storage capacity for water available to the crop in this typical "Kikuyu Red Loam" lateritic clay soil is 8–9 in. in the first 6 ft., varying somewhat with the depth of true topsoil remaining: below 6 ft., storage is about 1 in. per foot, so that the total storage capacity for available water in the first 10 ft. is between 12 in. and 13 in. This quantity will saturate the first 3 ft., and the surplus water will slowly percolate to 10 ft., which is well within the measured root range of mature coffee in these soils. When this extreme of drying is reached the deep Kikuyu Red Loam subsoil is heavily cracked. These cracks can cause water loss beyond the root range when very heavy irrigations are given, and if water scarcity is more important than distribution costs, it is better to make up a heavy deficit by instalments.

STORAGE OF FLOODWATER

An overriding practical consideration must be the dates at which the water is available from the rivers. The Kenya Water Apportionment Board has decided that floodwater may be abstracted between 1st April and 10th June, and also between 15th October and 10th January. In years when river conditions permit, one "spot application" of 2 in. only will be sanctioned between 1st July and 30th September.

It can be seen from Table 1 that the maximum possible 2-in. "spot application" in August would not have been sufficient to make up the soil moisture deficit in all years. It may, nevertheless, produce a substantial beneficial effect. Experimentation at this stage must aim to assess crop response to the full water requirement when supplied at this time, for if coffee should be found to respond most profitably to water in August, storage of floodwater may be economically sound. Since this "crop-saver" will not be available from the rivers during August in those very dry years in which the coffee will need it most, planters who wish to rely on an August irrigation must clearly provide storage in dams. Although evaporation rates are relatively low at this time of the year, such storage involves expensive evaporation losses. The estimated evaporation loss from dams at Ruiru from 1st June to 31st August is given for the past six years in Table 2.

The effects of the two rain seasons and the three permissible irrigation seasons are simply illustrated in Fig. 2. All the combinations shown are now under test at the Coffee Research Station, Ruiru. The diagram illustrates soil moisture storage changes in a fairly dry year in which the long rains fill the soil in the root range to field capacity, while the short rains fail to do so. The irrigations meet the calculated soil moisture deficit on each occasion.

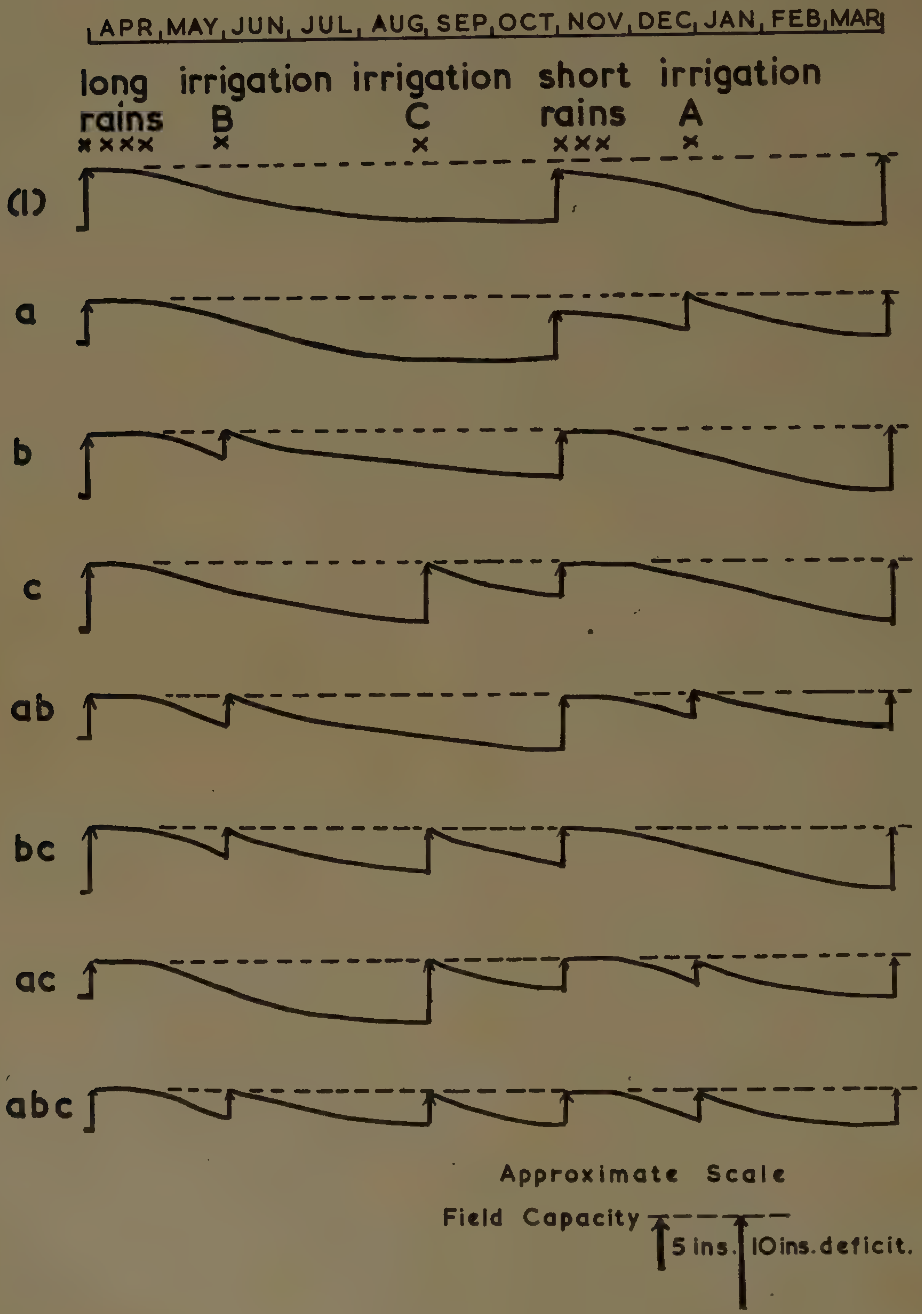
EXPERIMENTAL IRRIGATION AT RUIRU

Where water is supplied by pipe to a bunded pond under each tree, far less water can be used. In these experiments the bunds have been made rectangular, 4 ft. × 4 ft., to permit "Modified Rotovator" tillage in both directions, and thus to minimize hand weeding. Detailed calculations based on measured soil properties and on the root distribution studies made by Mr. R. W. Rayner,

TABLE 2.—APPROXIMATE EVAPORATION LOSSES FROM OPEN WATER AT RUIRU BETWEEN 1ST JUNE AND 31ST AUGUST (IN INCHES)

	1950	1951	1952	1953	1954	1955	1956
Rainfall	2·5	9·0	1·5	3·5	8·9	2·1	2·4
Evaporation	7·2	7·8	7·8	9·0	7·4	8·8	7·9
Net Gain or Loss	−4·7	+1·2	−6·3	−5·5	+1·5	−6·7	−5·5

Fig. 2.—Annual patterns of soil moisture deficit under coffee irrigation treatments



suggested that for this method one-half the quantities delivered by the overhead sprinkler system would be appropriate. In this case the soil moisture deficit is being met only for the limited area containing the greater part of the root system of the trees. The comparison between this system, which saves water at the expense of labour, and the overhead system, is one of the main objects of the field study now under way at the Coffee Research Station.

The practical problems of the overhead and piped ground distribution of measured quantities of water to 54 separate plots were solved by the Coffee Research Station staff in time to apply the first watering to supplement the long rains in 1956. The overhead sprinklers delivered 4 in. overall, while water equivalent to 2 in. over the whole plot was run into the basins under the trees.

In order to compare the soil moisture distribution resulting from these two methods of application, very heavy waterings were made at the end of August. Five days later sampling crews from E.A.A.F.R.O. took over 100 soil samples in the root zone under the trees. The results showed that both methods had wetted this root zone equally, within the limits of the sampling error, and thus confirmed the calculation that one-half the overhead watering would be appropriate under the trees.

At the end of the year a comprehensive set of soil samples were taken to a depth of 10 ft., both in mid-row and as close to the trees as it was possible to drill. The average water deficit was 6.8 in., while the six-year running balance of crop-water-use calculations gave a deficit of 6.9 in. It must be admitted at once that so close an agreement was partly accidental, since the soil moisture sampling gave an average total water content of 41.2 in. in 10 ft. of soil with a standard error of ± 0.8 in., but even this is of greater accuracy than the measurements the planter will be able to make of the water he applies in irrigation.

When a full year of watering treatments has been given, and comparative crop yields are available, a more comprehensive study of the water distribution in the root zone and between the trees will be undertaken. The scale of field and laboratory work required will be somewhat formidable.

ADVISORY SERVICE FOR PLANTERS

In the meantime, sufficient progress has been made to offer an advisory service to east-of-Rift planters who are irrigating coffee. These estimates are for well-managed healthy coffee in which transpiration is not limited by disease and the root system has not been damaged by severe overbearing. Excessive cropping can cause severe dieback of roots (Nutman, 1933) and this has been found by direct experiment to restrict the subsequent uptake of water by the coffee (Pereira, 1950). Estimations of soil moisture deficit in Table 1 were made on a 10-day basis, although only the figures at the end of each month are given in the table. While summaries of results will be published from time to time in the Bulletin of the Coffee Board of Kenya, this involves submission of data for printing some time in advance. Arrangements are therefore being made by which planters who request this service may submit their rainfall data and be advised directly by telegram from the Coffee Research Station, as to the approximate soil moisture deficit which they have to meet. E.A.A.F.R.O. staff will continue to soil-sample periodically to check the estimates and to improve the methods of calculation.

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EAST AFRICA MILK RECORDS OF LEADING COWS— JUNE TO DECEMBER, 1956

By the East African Milk Recording Scheme, P.O. Box 478, Nakuru, Kenya

CLASS I (UNDER 2 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records					
				No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
D. W. Crichton-Mackie, North Kinangop.	Annette 26, *Ayrshire Park Senator.*	Ayrshire N.P.	19–8–54	1st	19–11–55	6,492	251	4·25	275·9
J. E. Kidman, Limuru ..	Mthanga Heather, *Deyne Marnix Koerier.*	Friesland P	5–6–54	1st	31–12–55	7,106	305	3·85	273·6
Barclay Estates Ltd., Menengai	Emma 1483, *Grade 346.*	Friesland N.P.	8–11–53	1st	20–7–55	6,330	305	3·99	252·5
Osirua Jerseys, Limuru ..	Osirua Double Ophelia, *Louise's Double.*	Jersey P	2–7–53	1st	3–6–55	3,659	278	5·62	205·6
Osirua Jerseys, Limuru ..	Queen's Shilling, *Pearcelands Volunteer.*	Jersey N.P.	11–9–53	1st	31–8–55	6,070	305	5·70	346·0

CLASS II (UNDER 2½ YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
Kivulini Ltd., Molo	Kivulini Lexie 37th, *Kivulini Notable.*	Ayrshire P	11–2–53	1st	13–5–55	7,729	283	3·98	307·6
Lesirko Ltd., Ol'Kalou ..	Lesirko No. 1023, *Denbigh Punch.*	Ayrshire N.P.	7–11–52	1st	7–4–55	8,424	305	4·02	338·6
(*e*) Barclay Estates Ltd., Menengai.	Menengai Goddess 2nd, *Roland C VII.*	Friesland P	11–6–53	1st	8–11–55	12,494	305	3·94	492·2
Estates and Investments Ltd., Kitale.	Naisabu No. 54, *Oldmaster Mylord.*	Friesland N.P.	16–1–53	1st	9–7–55	7,389	243	3·87	285·9
Amberley Estate Ltd., Kiambu	Larash Prima, *Violets Truimph of Hever.*	Guernsey P	4–6–53	1st	8–9–55	6,295	305	4·46	280·7
Col. J. M. Graham, Njoro ..	Belinda G. 19, *Chettles Claude.*	Guernsey N.P.	26–3–53	1st	17–8–55	7,460	305	4·43	330·4
Sigona Jerseys, Kikuyu ..	Pearceland's Rosette, *Nderit Rosette's Beacon.*	Jersey P	25–7–53	1st	23–11–55	6,442	297	5·61	361·4
Southernwood Jerseys, Ainabkoi	Swara's D'Robo, GA6, *Southernwood Edna's Pioneer.*	Jersey N.P.	14–7–53	1st	15–10–55	5,637	305	6·19	348·9

NOTE.—P.—Pedigree. N.P.—Non-Pedigree. (*e*) Three times milking.

CLASS III (UNDER 3 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed		Date of Birth	Lactation Records					
					No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
Chartley Farm, Nakuru ..	Hafod Marguerite 3rd, *Kivulini Kate's Baron.*	Ayrshire	P	13–12–52	1st	25–6–55	10,470	305	3·85	403·1
Lesirko Ltd., O.'Kalou ..	Lesirko No. 1017, *Ayrshire Park Silverlink.*	Ayrshire	N.P.	7–8–52	1st	22–6–55	7,935	305	4·14	328·5
(*e*) Gingalili Ltd., Nakuru ..	Gingalili Ailsa, *Oldambster Annie's Eduard.*	Friesland	P	2–2–53	1st	12–8–55	7,478	272	4·36	326·0
Wolstaston Estate, Menengai	1 of 3 Gileges, *Oldamster Mylord.*	Friesland	N.P.	9–1–53	1st	1–12–54	7,225	215	3·65	263·7
					2nd	15–11–55	10,545	296	3·59	378·5
Broomhill Estate Ltd., Kiambu	Defiance's Juniper of Broomhill, *Cherkley Defiance.*	Guernsey	P	7–9–52	1st	5–8–55	7,289	305	5·39	392·9
Ol'Bonata Ltd., Nakuru ..	Matatu 2 No. 8, *Daisy Midshipman of Iford*	Guernsey	N.P.	8–12–52	1st	8–9–55	7,740	305	5·08	393·2
Mrs. J. W. Graham, Nairobi	Mkinduri Royal Fancy, *Sigona Rajah's Beauty.*	Jersey	P	3–12–52	1st	6–9–55	6,597	305	5·23	345·0
Peet Estates, Ltd., Nakuru ..	Belinda 5, *Unknown.*	Jersey	N.P.	Unknown	1st	22–8–54	3,952	266	5·88	232·4
					2nd	26–7–55	5,383	305	5·99	322·4

CLASS IV (UNDER 4 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed		Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
A. J. Stewart, Njoro	Stewart's Maid 2nd, *Eglinton Mains Elegance.*	Ayrshire	P	21–8–51	1st	15–9–53	6,327	292	3·96	250·5
					2nd	13–8–54	7,229	289	4·02	290·6
					3rd	13–7–55	9,487	287	4·48	425·0
A. J. Stewart, Njoro	Naivasha 6th No. 368, *Eglinton Mains Elegance.*	Ayrshire	N.P.	5–6–52	1st	7–10–54	7,276	288	4·65	338·3
					2nd	20–9–55	8,500	305	5·01	425·8
(*h*) (*e*) Gingalili Ltd., Nakuru	Jantje A.9 (Imp.), *Reintje's Eduard.*	Friesland	P	27–7–51	1st	9–4–54	6,039	275	4·78	288·7
					2nd	15–5–55	9,381	283	4·21	394·9
(*e*) Gingalili Ltd., Nakuru ..	Pixie II, *Unknown.*	Friesland	N.P.	Unknown	2nd	23–10–55	11,052	305	3·53	390·1
Blundell Estate, Nakuru ..	Cardington Rosey, *Ware Roses Butterpats.*	Guernsey	P	18–12–51	1st	16–4–54	6,833	299	4·36	297·9
					2nd	5–9–55	7,494	302	4·48	335·7
P. E. L. Howard, Nakuru ..	Chemuryet 2 H.44, *Cardington Robert, 6th.*	Guernsey	N.P.	8–4–52	1st	27–9–54	7,090	289	5·26	372·9
					2nd	13–9–55	7,970	295	4·98	396·9
Osirua Jerseys, Limuru ..	Olivia's Dewdrop C.M. (Imp.), *Lady Olivia's Boy.*	Jersey	P	29–9–51	2nd	25–8–54	8,035	305	5·09	408·9
					3rd	17–8–55	9,703	305	4·62	448·3
Mrs. M. Repton, Gilgil ..	Marula, *Unknown.*	Jersey	N.P.	Unknown	1st	4–12–54	5,298	268	6·21	329·0
					2nd	6–11–55	6,980	305	6·53	455·7

NOTE.—P.—Pedigree. N.P.—Non-Pedigree. (*e*) Three times milking. (*h*) Withdrawn in milk.

CLASS V (UNDER 5 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records					
				No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
Kivulini Ltd., Molo	Kivulini Phylida 28th, *Mtarakwa Neptune.*	Ayrshire P	11–1–51	1st	26–8–53	6,263	305	4·52	283·1
				2nd	29–7–54	7,914	258	4·18	330·8
				3rd	12–7–55	10,282	296	4·95	508·9
(*h*) J. L. Downey, Limuru	Square 6th, *Mtarakwa Masterpiece.*	Ayrshire N.P.	5–2–51	1st	9–7–54	8,987	295	4·52	406·2
				2nd	1–7–55	10,456	247	4·38	457·9
(*d*) Gingalili Ltd., Nakuru	Gingalili Orris, *Rutje's Eduard III.*	Friesland P	8–10–50	1st	6–1–53	9,840	305	3·57	351·3
				2nd	29–6–54	9,371	305	3·79	355·1
				3rd	5–9–55	8,493	302	3·88	329·5
J. E. Kidman, Limuru	Bess, *Norman.*	Friesland N.P.	5–4–51	2nd	20–7–55	12,059	305	3·34	402·7
Blundell Estate, Nakuru	Beauty's Pride 4th of Clos Hoguet (Imp.), *Columbus of Maple Lodge.*	Guernsey P	20–8–51	1st	9–8–54	5,352	297	5·11	273·4
				2nd	9–9–55	7,099	305	5·28	374·8
Rhodora Estates Ltd., Nakuru	Rumaval 2nd B.32, *White Ladies Champion 8th.*	Guernsey N.P.	14–9–50	1st	7–6–53	5,801	305	4·73	274·3
				2nd	23–6–54	8,365	305	5·11	427·5
				3rd	4–7–55	11,863	305	4·80	569·4
Osirua Jerseys, Limuru	Kaesong of the Lake C.M. (Imp.), *La Fontaine Dreamster.*	Jersey P	23–7–51	2nd	7–6–54	5,703	305	5·77	329·0
				3rd	27–8–55	7,155	296	6·10	436·5
(*e*) R. A. Clay, Elburgon	Croix's Marietta IV No. 5, *La Croix Maharajah.*	Jersey N.P.	21–4–51	1st	29–4–53	4,105	272	6·03	247·5
				2nd	4–5–54	6,372	305	5·81	370·2
				3rd	19–10–55	8,503	305	5·98	508·5

CLASS VI (MATURE)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
A. J. Stewart, Njoro	Mtarakwa Millicent, *Benmore Yeoman.*	Ayrshire P	14–6–45	7th	21–6–53	10,578	297	3·97	419·9
				8th	25–5–54	10,989	305	3·50	384·6
				9th	4–8–55	14,027	305	4·10	575·1
J. L. Downey, Limuru	Marina 9th, *Mtarakwa Masterpiece.*	Ayrshire N.P.	Unknown	1st	27–7–52	7,870	275	4·36	343·1
				2nd	29–6–53	11,045	305	4·19	462·7
				3rd	15–4–55	11,698	305	4·07	476·1
(*e*) Barclay Estates Ltd., Menengai.	Bradwall Emperor's Lorna, A.R. (Imp.), *Bradwall Lodge Emperor.*	Friesland P	10–10–48	2nd	6–8–52	14,963	305	3·51	525·2
				3rd	21–2–54	20,386	305	3·32	676·8
				4th	23–9–55	18,478	305	3·43	633·8
Gingalili Ltd., Nakuru	Pixie I, *Unknown.*	Friesland N.P.	16–9–48	2nd	21–9–54	11,952	256	3·63	433·8
				4th	24–8–55	14,589	305	3·61	526·6
(*e*) Rhodora Estates Ltd., Nakuru.	Malverley's Juna 8th A.R. (Imp.), *Fernhill Rose's Triumph 5th.*	Guernsey P	15–11–48	3rd	8–3–53	10,477	305	4·59	480·9
				4th	11–4–54	10,185	305	4·43	451·2
				5th	6–5–55	12,750	305	4·86	619·6
(*e*) Rhodora Estates Ltd., Nakuru.	Buttercup 2nd 75, *Fernhill Robert's Lad 10th.*	Guernsey N.P.	8–6–48	4th	19–8–54	8,101	305	4·23	342·7
				5th	21–10–55	9,879	305	4·67	461·3
(*e*) R. A. Clay, Elburgon	Dinarzade C.M. (Imp.), *Maharajah of Rosel.*	Jersey P	8–7–47	4th	22–4–53	7,232	305	5·83	421·6
				5th	19–6–54	7,509	304	5·76	432·5
				6th	17–11–55	7,480	305	5·94	444·3
(*e*) D. E. Fielden, Nakuru	Wanja 3 No. 274, *Milpomenes Dreamer.*	Jersey N.P.	28–1–50	2nd	1–7–53	6,271	249	5·53	346·8
				3rd	30–5–54	8,186	293	5·39	441·2
				4th	28–5–55	9,121	305	5·37	489·8

NOTE.—P.—Pedigree. N.P.—Non-Pedigree. (*d*) Aborted Lactation. (*e*) Three times milking. (*h*) Withdrawn in milk.

A BORON DEFICIENCY IN SISAL (AGAVE SISALANA PERRINE)

By **E. C. Diekmahns, Sisal Research Station, Mlingano, Tanganyika**

(*Received for publication on 4th February, 1957*)

During the course of sand culture investigations at Mlingano dealing with the macronutrient status of sisal plants, a new leaf symptom was observed. This symptom took the form of a cracking of the leaf epidermis, but it only occurred on well-developed plants with 25 leaves or more and on plants which were at least 30 cm. high. Plants were affected more or less irrespective of the macronutrient treatment. All these plants received a complete micronutrient solution but the occurrence of the symptom on these large plants suggested that the supply of one of the micronutrients might be approaching a level of deficiency.

In a new series of studies on the micronutrient nutrition of sisal, a similar leaf symptom developed on sisal growing in both sand and water cultures which were lacking in boron.

Two sizes of plants were used in the sand culture experiment, bulbils which were five centimetres tall and plants from a field nursery which were twenty centimetres in height. Both kinds were planted in acid-washed sand contained in ten-inch horticultural clay pots painted on the inside with a bitumen paint. All chemicals supplying the macronutrients were of Analar grade and they were recrystallized three times before use; water distilled from a standard still through a pure tin condenser was used throughout the experiment. The nutrient solutions, whether complete or lacking in boron, were applied three times per week.

As regards the water culture experiment, five-centimetre tall bulbil plants were grown in the same solutions as those mentioned above. The culture solutions were not aerated but instead were renewed at weekly intervals.

The plants in both the sand and water culture experiments showed identical symptoms after 12 weeks' growth in all the treatments which were lacking in boron. The first symptom to appear is a yellow speckling of the upper and lower leaf surfaces. This is usually, but not exclusively, confined to the distal half of the leaf and it is followed almost immediately by a superficial "cracking" of the epidermis. Cracking can occur anywhere on the leaf surface and it normally begins as a single crack at the leaf margin, later branching across the lamina of the leaf. When the surface becomes badly wrinkled this results in irregular sunken areas and the distortion of the epidermis may be accompanied by suberisation (Plate I). This leaf cracking is always most severe on the last unfurled leaf and sometimes on spike leaves the distal end has the appearance of being severed a few millimetres from the tip (Plate II). In some cases the normally smooth edge of the leaf becomes notched according to the location of the cracks. Other symptoms are a poor development of the root system, an insignificant tip thorn, and a tendency for the tip of the leaf to be hooded; this latter effect may be caused by a restriction of growth along the leaf margins.

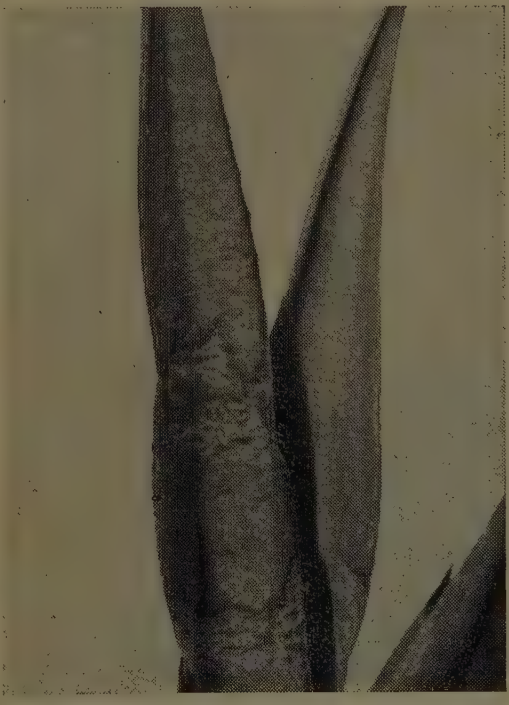

Plate I.—Boron deficiency in sisal

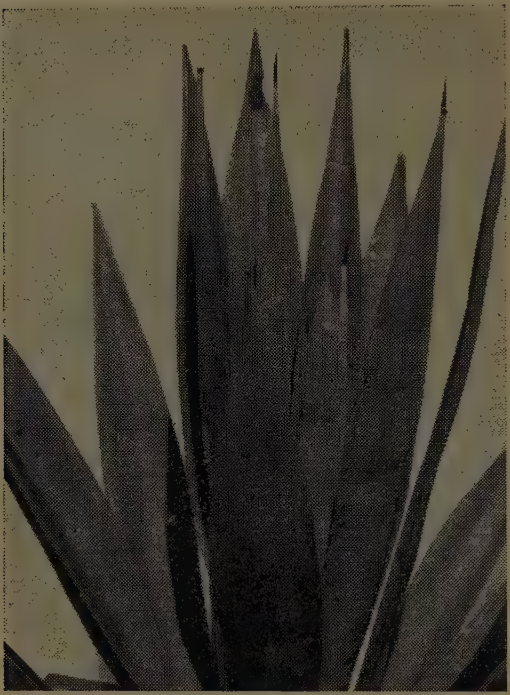

Plate II.—Boron deficient plant showing leaf cracking, shortening of the spike and the absence of tip thorns on spike leaves

Besides these symptoms, the growing point and meristem also appear to become disorganized. New leaves are short and stubby and do not readily unfurl and this accentuates the bulbous appearance of small plants.

Some 18-months-old sisal growing in sand culture, which had received a full nutrient solution with the expection of all micronutrients, developed symptoms similar to those just described. In this experiment there was no attempt to purify the nutrient salts, although Analar grade chemicals were used, but the water supply was purified by passage through anion and cation exchange resins. The symptoms in this case were most severe, and the last unfurled leaf was only one-quarter of the length of the leaves unfurled six to nine months previously (Plate II).

When boric acid at 0.66 p.p.m. was incorporated in the nutrient solution applied to these plants, recovery was rapid and the new leaves were free of speckling and epidermal cracking, in addition to regaining their normal length within ten weeks. The hooded-tip effect and absence of a tip thorn was still obvious on all the unfurled leaves 15 weeks after the application of the boric acid although new leaves within the spike appear to be normal in this respect. These observations suggest that leaf cracking of sisal leaves is attributable to a deficiency of boron and further investigational work is being undertaken.

Leaf cracking of sisal has been observed in the Korogwe area of Tanganyika where the soils are red earths derived from gneiss. Similar symptoms have been noted on sisal estates in the Northern Province of Tanganyika where volcanic soils occur.

The permission of the Tanganyika Sisal Growers Association to publish this note is acknowledged.

REVIEW

OATS—THEIR CULTIVATION AND USE FROM ANCIENT TIMES TO THE PRESENT DAY, by W. M. Findlay. Aberdeen University Studies No. 137. Oliver and Boyd, Edinburgh. 1956. Price Sh. 21.

In the 200 pages of this book, completed shortly before his death, William Maitland Findlay has placed on record his great knowledge of oats collected over a busy lifetime. Its chapters cover early history and the improvement of varieties that has taken place during the 19th and 20th centuries; cultural methods; milling; and finally the use of oats as food. It is primarily a book for the farmer—and especially the Scottish farmer, for all Findlay's experience was obtained in Scotland.

The book is pleasant to read. In style its writing flows easily; it avoids the extreme compression into which present-day demands for economy so often force an author and make his writing heavy and indigestible. But we may, perhaps, regret that, unlike most modern books of its kind, it is entirely devoid of illustrations —except for a frontispiece portrait of the author.

H. H. S.

EFFECTS OF POPULATION DENSITY ON YIELD OF MAIZE

By J. S. Hemingway, Plant Pathologist, Tanganyika Agricultural Corporation

(*Received for publication on 18th December, 1956*)

The name "Katumbili" is used for white-seeded maize grown over wide areas of East Africa. In its crude form, as grown largely in native cultivation, the stock contains a very great mixture of characters: dent- and flint-seeded types, tall, intermediate and dwarf plants, variations of ear number and row number on the ear, a range of growth periods, other coloured seeds, etc. Attempts have been made in many areas, particularly on experimental farms, to "clean up" this mixture by mass-selection and other simple techniques, in order to standardize strains which conform to local necessities (length of season, etc.), and preferences (dent or flint, "sugary" or "starchy" seed, etc.). As a consequence of these attempts a number of fairly distinct strains have been named, and these are in use in breeding programmes and in the East African co-operative maize variety trials currently being run on a number of experimental farms. Examples of such strains are "Katumbili Mwanza", "Katumbili Namulonge", "Katumbili Kilosa" and "Katumbili Nachingwea".

"Katumbili Nachingwea" has been developed from the crude stock by recurrent selection on farms owned by the Tanganyika Agricultural Corporation at Nachingwea, in the Southern Province of Tanganyika. During the last five years selection for general conformity to type has been practised, usually when sorting ears before shelling for seed. Ears which were small, diseased, flint-seeded, of low row numbers, containing off-colour seed (particularly pink seed), or were inadequately covered by the sheath have always been discarded. The most noticeable effect of this mass-selection has been on seed type: the maize crop from the 4,500 acres grown at Nachingwea is now predominantly dent, and virtually free from contamination by yellow or other coloured seeds. The usual planting time for maize is the first three weeks of January, and such plantings mature in 100–115 days. At normal field populations there are usually few "passenger" plants failing to produce an ear (except in localized patches of poor fertility); few plants produce more than one ear, so that the overall average is generally slightly under one ear per plant. The ears predominantly bear 10–12 rows of seed.

The crop yield is influenced by three main factors: soil fertility, moisture and population. The date of planting is of importance in relation to the moisture factor, the expectation of adequate rain falling on maize planted after the end of January being low [1]. Late plantings suffer severe reductions of yield due to the epidemic of American maize rust (*Puccinia polysora* Underw.). Detailed study has been made [2] of the intrinsic effects of this rust in causing the reduction of yield: it is mainly a result of lower mean numbers of ears per plant, and considerably lower individual seed weights. This paper reports studies of the ways in which the various components of yield are affected by a wide range of plant populations.

Exploratory experiments at Nachingwea in 1951 showed the necessity of establishing high plant populations to achieve good yields. Whereas a population of 4,400 plants per acre yielded 1,966 lb. seed, 10,100 plants yielded 3,302 lb. seed. Row widths varying between 28 in. and 42 in. had no effect on yield at similar populations. The present practise at Nachingwea is to plant on ridges made at 34-in. or 36-in. centres; thus, with the aim of establishing populations of the order of 10,000 per acre, a spacing of approximately 18 in. between plants in the row is necessary. Actual stands range between approximately 24-in. and 15-in. spacing in the row (i.e. 7,700 to 12,300 per acre). Unless planting conditions are optimum for germination and emergence the common practice is to sow rather thickly, and to thin out the plants later to leave the desired stand. Reductions of the population during growth are mainly a result of attack by pests—stem borers and termites being particularly damaging on occasions.

The present studies were made in the 1956 season on a range of populations between 5,125 to 46,123 per acre. Plots were planted with three seeds per hole at distances of 4, 6, 9, 12, 18, 24 and 36 in. apart, on ridges at 34-in. centres. The plots were not replicated, but were sited at random. After emergence the plants were thinned to leave only one per hole. The experiment was sited on a sandy loamy soil of the "Nachingwea red" series; 100 lb. per acre of single superphosphate was placed in the ridges before planting and 1 cwt. per acre of sulphate of ammonia was applied by hand as a top-dressing when the plants were six weeks old. These are standard amounts of fertilizer applied to maize in the Nachingwea area. The plots were kept clean-weeded, and no incidence of *Striga* spp. was observed. In the duration of the experiment (planted 17th January, harvested 1st May) 34.89 in. of rain were recorded: the season as a whole was a wet one, with no pronounced drought periods, and the total rainfall was substantially above the local average. At harvest the ears of 100 consecutive plants in each plot were picked and individually labelled with a serial number. The ears were packed loosely in boxes in the laboratory until they were completely dry.

When the ears were ready for shelling the required records were made. The number of rows of seed on each ear was counted, and the overall length of the cob, and the length of it bearing seed were measured. Each ear before shelling and the seed after shelling were weighed on a gram scale. From these figures the total ear weight and seed weight for each 100-plant sample, and hence the mean ear weight and seed weight per acre, per plant and per plant producing seed (i.e. not counting the "passengers"), and the shelling percentage of the whole sample, were calculated. For each sample the distributions of row numbers, lengths of cob bearing seed, seed weights and shelling percentages were worked out and also the distribution of plants without ears, or with one, two, three or four ears. The seed from the whole 100-plant sample was thoroughly mixed and four sub-samples of 100 gms. each were taken for seed counts, and hence calculation of the number of seed per pound.

YIELDS

In Fig. I are shown the effects of the various populations on the yields of seed per acre, per plant (i.e. mean of each recorded sample of 100) and per productive plant (i.e. mean of the plants in each sample producing seed).

The yield per acre rose rapidly as the population increased up to 15,000 plants and remained fairly steady at 2,600–2,700 lb. seed per acre between the populations of 15,000 and 30,000. At the highest population of 46,000 plants per acre the yield was below the maximum, and only equal to that obtainable with 6,500 plants.

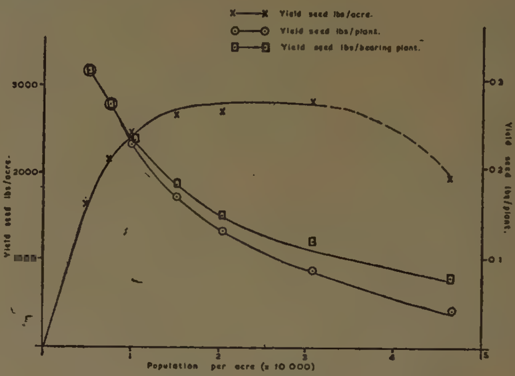

Fig. I.—Effect of population on yield

The curve of the mean yield per plant falls from 0.315 lb. per plant at the lowest populations to 0.042 lb. at the highest: that for the mean yield of the productive plants only diverges gradually as the percentage of "passenger" plants increases with the population.

YIELD DISTRIBUTION

This increase in the percentage of non-productive "passengers" is shown in Fig. II; the distributions of each sample in the various yield groups are also shown. At populations under 10,000 plants per acre there were no "passengers", whereas 47 per cent failed to bear at the level of 46,000 plants.

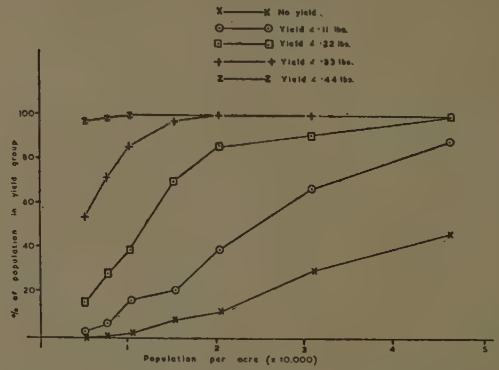

Fig. II.—Distribution of yield groups within populations

At the 20,500 plant population, which gave almost the optimum yield per acre (2,685 lb.

seed), the mean yield per plant of 0.13 lb. was made up of 11 per cent "passengers", 28 per cent in the group yielding 0–0.11 lb. (i.e. 0–50 gms.), 47 per cent yielding 0.11–0.22 lb. (50–100 gms.) and 14 per cent yielding 0.22–0.33 lb. (100–150 gms.). At that level of population no individual plants yielded more than 0.33 lb. seed. At the lowest population of 5,125 plants per acre, 44 per cent yielded 0.33–0.44 lb. seed and three individuals produced 0.45, 0.46 and 0.48 lb. respectively.

COMPONENTS OF YIELD

The main components of the yield per plant are the number of ears, the number of rows of seed on the ear, the length of ear which bears seed, and the individual seed weight.

Ear Numbers.—In Fig. III the effect of the increasing population on the mean number of bearing ears per plant is shown: the numbers fall steadily from 1.07 ears per plant at the lowest to 0.53 ears per plant at the highest population. Multiple-eared plants are very uncommon in "Katumbili Nachingwea"; at 5,000 plants per acre only 7 per cent bore two ears and at 15,000 only 1 per cent. When a plant bears two ears they are usually unequal in size, the second rarely bearing half as much seed as the main ear.

Row Numbers.—Fig. III also shows the slight reduction of the mean numbers of rows of seed on each bearing ear, from 11.5 at 5,000 plants to 10.1 at 46,000 plants. This was rather a surprising effect of population. The distribution of row numbers per ear is shown in Table I.

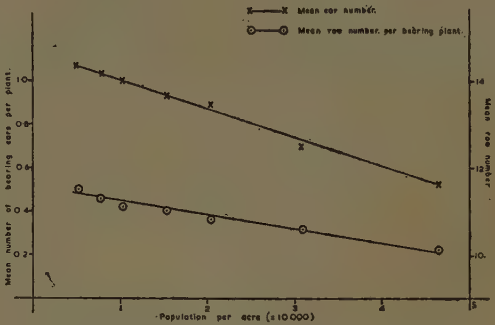

Fig. III.—Effects of population on mean ear number and row number per ear

Ear Lengths.—When the recordings were made, the length of the seed-bearing part of each ear was measured. The calculated mean ear lengths per plant producing seed are shown in Fig. IV; there is a gradual fall from 7.56 in. at the lowest population to 2.16 in. at the highest.

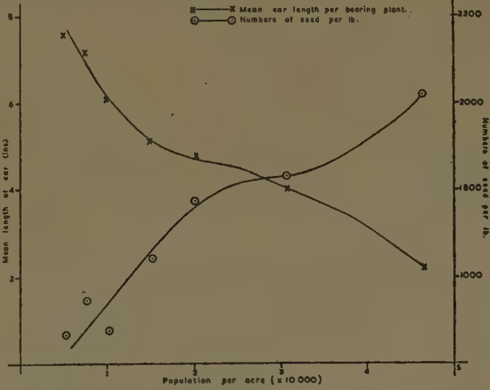

Fig. IV.—Effects of population on length of ears and on seed weights

TABLE I—DISTRIBUTION OF ROW NUMBERS PER EAR AT VARIOUS PLANT POPULATIONS

Population per acre	Rows of Seed Per Ear							
	0	8	10	12	14	16	18	Mean per productive plant
5,125	0	2	38	46	13	1	0	11·5
7,687	0	4	46	34	12	3	1	11·3
10,249	1	7	45	34	13	0	0	11·1
15,374	7	5	46	33	8	1	0	11·0
20,498	11	9	47	23	10	0	0	10·8
30,748	25	8	42	21	4	0	0	10·6
46,123	47	13	24	16	0	0	0	10·1

The term "nubbin" is usually applied to ears of less than 5 in. in length. In Table II is shown the distribution of such "nubbins" in each population.

Seed Weights and Numbers.—Fig. IV also demonstrates the rapid increase in the numbers of seed per lb. as the plant population increases; thus at the lower population the individual seeds are considerably heavier and larger.

From these seed weights the actual number of seeds produced per plant have been calculated, and in Fig. V is shown the effect of population on the mean numbers of seed per plant, and per plant producing seed. At the highest population there are only a third as many seed per producing plant as at the lowest (160:461).

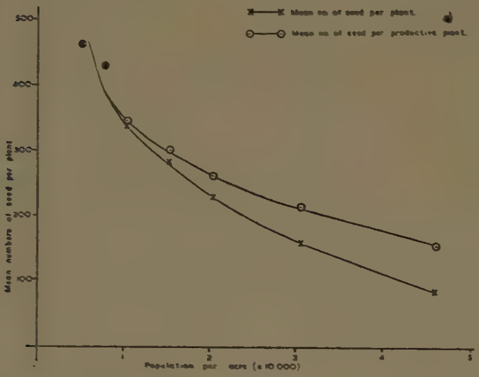

Fig. V.—Effect of population on numbers of seed per plant

SHELLING PERCENTAGE

As the individual seeds on the plants growing at low populations are heavier and more numerous, such populations show a higher shelling percentage, i.e. the weight of seed as a percentage of the total weight of the ear. The range of these percentages, calculated from the total seed and ear weights of each sample are given in Table II.

SUMMARY

In the reported study the maximum level of yield was obtained with plant populations between 15,000 and 30,000 per acre. At lower populations the individual yielding ability of plants of "Katumbili Nachingwea" was unable to compensate completely and at higher populations excess competition reduced the total yield. The large population range over which the maximum level of yield was obtained suggests the adaptability of this variety over a wide range of growth conditions.

An increasing percentage of "passenger" plants, lower ear numbers, lower seed row numbers on the ear, shorter ear lengths, lighter and fewer seed per plant and lower shelling percentages were closely associated with increasing populations.

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TABLE II—SHELLING PERCENTAGES AND DISTRIBUTION OF "NUBBIN" EARS AT VARIOUS PLANT POPULATIONS

Population per acre	Shelling percentage	"Passengers"	Ears under 5 in.	Ears over 5 in.	Mean ear length
5,125	81·5	0	8	92	7·18
7,687	81·3	0	8	92	7·18
10,249	80·1	1	25	76	6·10
15,374	79·8	7	53	40	5·10
20,498	80·0	11	59	30	4·76
30,748	78·4	25	62	13	4·00
46,123	75·7	47	50	3	2·16

SAPROPHYTIC FUNGI AS DESTROYERS OF GERMINATING PINE SEEDS

By I. A. S. Gibson, Forest Department, Kenya

(*Received for publication on 16th January, 1957*)

In trials of *Pinus patula* Schl. & Cham. seeds it was observed that damage to the testa resulted in a complete failure of germination. Experiments to confirm this observation were carried out using lots of 50 seeds germinated on damp filter paper at 26° C., either undamaged or with the testa pierced with a sterile needle. The results of these not only bore out preliminary observations but showed that pierced seeds became colonized lightly by various saprophytic fungi. It seemed therefore that failure to germinate could be due to mechanical damage or subsequent fungal invasion. Practical experience elsewhere has shown [6], [8] that mechanical de-winging of pine seeds can lead to considerable reduction of germination, presumably through damage to the testa brought about by processing, and subsequent experiments have been carried out to determine how far this may be due to mechanical or fungal agencies and to investigate the conditions under which fungal attack may take place.

To determine the relative importance of fungal and mechanical damage in causing germination failure an experiment was carried out comparing the germination of whole *P. patula* seeds with others surface-sterilized by immersion in 0.1 per cent mercuric chloride for two minutes followed by a wash in sterile water. The latter were subsequently divided into two lots one of which had the testa pierced with a sterile needle. The germination of lots of 250 seeds from each of these three treatments was compared under sterile conditions on water agar in petri dishes at 26° C. After 15 days untreated seeds gave 76.4 per cent germination, sterilized seeds 71.6 per cent and sterilized and pierced seeds 64.5 per cent indicating that, while some germination failure might be attributed to mechanical damage the greater portion of that observed above must have been due to other agencies, presumably fungal.

The fungi associated with seeds of *P. patula* were first examined by incubating seeds singly in sloped tubes of sterile 0.2 per cent malt agar; 90 tubes were set up in this way with undamaged seeds and 24 more with seeds of which the testa had been pierced. After incubation at 26° C. for three days the fungi growing in the tubes were recorded and it was found that the same species occurred with approximately the same frequency in tubes with sound and with pierced seeds, indicating that piercing of the testa did not cause gross selective effects favouring the development of one fungus. Complete failure of germination was later observed for the pierced seeds although about 60 per cent of the sound seeds grew satisfactorily under these conditions. It was concluded from these observations that no single fungus was likely to be responsible for germination failure, and to test this six fungi were isolated from this experiment at random. These were identified by the Commonwealth Mycological Institute as follows and were used in later experiments.

Rhizopus arrhizus Fischer (IMI 63323).

Mucor hiemalis Wehmer (IMI 63324).

Trichoderma koeningii Oudem (IMI 63325).

Cladosporium sp. (IMI 63326).

Aspergillus tamarii Kita (IMI 63327).

Chætomium cochliodes Palliser (IMI 63328).

The Relative Effects of Six Fungi on Germination of Pine Seeds (*Experiment 1*)

This was designed to test the relative effects of the six isolates on germinating seeds of *P. patula* either with or without testa perforation and at different times of inoculation. Seeds were set up, after surface sterilization and testa perforation (if appropriate), on sterile plates of 0.2 per cent malt agar and incubated at 26° C. This strength of malt had been found sufficient to allow some fungal growth without interfering with the rate of germination of the seeds. Fifty seeds per plate were sown, four plates per inoculant of which one pair were inoculated at the start of germination and another six days later; each of these pairs consisted of one plate of sound and one plate of treated seeds. Inoculation was made by adding 0.2 ml. of a thick spore suspension of the isolate on test to the plate. Counts were made of seedling survival 15 days after inoculation with results shown in Table I. Simultaneously the growth rates of the experimental fungi were measured at the temperature of incubation on 5 per cent malt agar.

TABLE I—THE EFFECTS OF A RANGE OF FUNGI ON THE GERMINATION OF SEEDS OF *P. patula* AT VARIOUS STATES OF DAMAGE AND GERMINATION

Isolate	Seed Damage	Survival of seeds 15 days after inoculation (ex total of 50)		Growth rate of Isolate (mm./24 hr.)
		Inoculated at time of setting to germinate	Inoculated 6 days after setting to germinate	
1. *Rhizopus arrhizus*	Nil	36	38	21
	Testa-pierced	0	26	
2. *Mucor hiemalis*	Nil	35	42	14
	Testa-pierced	17	36	
3. *Trichoderma koeningii*	Nil	38	39	17
	Testa-pierced	12	34	
4. *Cladosporium* sp.	Nil	38	38	2
	Testa-pierced	36	39	
5. *Aspergillus tamarii*	Nil	24	41	7
	Testa-pierced	8	16	
6. *Chaetomium cochliodes*	Nil	39	30	8
	Testa-pierced	29	31	
Nil	Nil	36 33	38 33	—
TOTAL		350	513	

The results clearly show that the faster-growing isolates are most likely to damage seed and that as germination proceeds susceptibility to this attack decreases. Under these experimental conditions the appearance of the rootlet tip occurred at about the seventh or eighth day after germination had been started and the late inoculation was applied just before this. As an exception, *Aspergillus tamarii* has shown a high capacity for seed destruction in relation to its growth rate in culture. This has not been investigated in detail, but it is perhaps worth noting that this species of *Aspergillus* has been recorded as a seed-destroyer elsewhere [9], [10], [12] and that its lipolytic enzymes [2] make it well equipped to invade the fatty storage tissue of pine seeds.

EFFECTS OF GERMINATION STAGE ON ATTACK BY SEED SAPROPHYTES (*Experiment 2*)

A more detailed examination of the effect of time of inoculation in relation to germination on susceptibility to fungal destruction of seeds of *P. patula* was carried out using methods similar to those of Experiment 1. Inoculations were made with *R. arrhizus* only into plates of 40 sound testa-pierced surface-sterilized seeds at various intervals after the start of germination. The experiment was carried out in two parts, in one test, seeds were pierced at the time of inoculation and in the other at the start of germination. The seedling survival under these various conditions (Table II) shows a progressive increase in resistance to attack by the pierced seeds with increasing age, irrespective of time of piercing. Where seedlings were attacked at time of appearance of the radicle the root tip was frequently destroyed.

TABLE II—THE EFFECT OF STAGE OF GERMINATION ON THE SUSCEPTIBILITY OF GERMINATING SEEDS OF *P. patula* TO ATTACK BY *Rhizopus arrhizus*

Time of inoculation (Days after seeds were set to germinate)	Survival of seeds 15 days after inoculation (ex total of 40)			
	Seeds pierced when set to germinate	Seeds pierced at time of inoculation	Sound Seeds	
0	1	1	19	22
2	3	—	30	—
3	—	6	—	26
4	5	—	26	—
5	8	—	25	—
7	—	16	—	25
Uninoculated control	25	26	—	26

These two experiments have demonstrated the possibility of fast-growing saprophytes invading pine seeds through very small wounds in the testa and inhibiting germination. Further tests have shown that surface sterilized seeds with pierced testas sown in normal moist soil completely fail to germinate, presumably through invasion by soil saprophytes. It seems possible that destruction of seeds in this way may be facilitated by the proximity of a relatively large food base, the seed reserves, adjoining the small volume of living tissue. If available nutrient can effect the capacity of saprophytes for seed destruction in this way, an increase in the nutrient status of a sterile medium in which seeds are germinating should result in increased destruction by introduced saprophytes. This has been tested in three experiments (all of similar design) giving similar results, only the most extensive of which will be described here.

Effect of Nutrient External to the Seed on Attack by Saprophytes (*Experiment 3*)

This was set up in flasks containing either 50 or 100 gm. of starch-sand mixtures at the following percentages of starch: 0, 0.4, 1.6, 4.0. These were plugged with cotton wool, sterilized and contained a small absorption tube of indicator soda-lime. Twenty-five surface-sterilized (*P. patula*) seeds were sown in each flask which were then inoculated with 0.2 ml. of a thick spore suspension of *R. arrhizus* in sterile water. The whole experiment was set up on the laboratory bench where it was observed daily, soda-lime being added to the absorption tubes as required. After 20 days the contents of the flasks were turned out and examined, both for survival of seedlings and for accumulation of acid staling products. The latter were detected at the highest starch level, where the pH had been reduced from about 6.0 to 4.8. Effects of nutrient level on seed destruction were apparent (Table III) at lower levels than this, so it is concluded that neither accumulation of acid staling products nor carbon dioxide accumulation can have been wholly responsible for seedling loss. As might be expected, fungal growth was vigorous in those flasks where a relatively high percentage of cornmeal starch had been included.

Application to the Soil Medium

It seemed possible from the results of these experiments that the sowing of seeds in rich soil media might promote conditions suitable for profuse fungal growth and seedling attack. Accordingly an experiment was set up based on pots of unsterilized soil to which cornmeal had been mixed to the same proportions as in Experiment 3; each treatment was in quadruplicate and each pot sown with 100 *P. patula* seeds. The resultant seedling emergence within this experiment showed no effects of soil additives on seedling survival. A similar experiment, in which soil with or without supplementary nutrient was watered with thick spore suspensions of *R. arrhizus* or *T. koeningii* or left untreated, gave the same results. In a small experiment it was also demonstrated that addition of 0.5 per cent cornmeal to sterile soil was followed by increase in germination loss of unsterilized seeds sown in this medium.

Table III—Effects of Available Nutrient on Pine Seedling Damage by *Rhizopus arrhizus* Under Sterile Conditions

Cornmeal, percentage in sterile sand	Mean survival out of 25 seeds	
	Flasks containing 50 gm. sand/ starch	Flasks containing 100 gm. sand/ starch
0	21	21
0·4	20	22
1·6	13	13
4·0	10	2
Replication ..	3 flasks	2 flasks

From these results it was concluded that nutrient only affected the destructive activity of saprophytes where competition for it was at a minimum, as it is within the seed coat or under conditions such as those of Experiment 3. Following this conclusion it only remained to be seen whether saprophytes, having colonized one seed could then spread more readily to destroy neighbouring seeds.

To test this a comparison was made up of the seedling emergence obtained from a series of lots of 100 seeds made up of different proportions of sound seeds to those with pierced testas. A randomized block design was used for this involving six percentages of sound seeds (100, 90, 75, 50, 25, 10) and seven replications, set up in flowerpots in the glasshouse. No damping-off was recorded in the emergent seedlings and no significant differences found in the percentage emergence of the sound seeds, assuming complete germination failure of the testa-pierced seeds. Thus a high proportion of damaged seeds was not found to affect the rate of germination of the sound seeds.

DISCUSSION

Previous investigators have shown that the wide range of fungal saprophytes to be found on the surface of pine seeds are very largely harmless [1], [3], [4], [5], [13], [14], [15] and in the case of the oak Potlaicuk [11] has gone so far as to distinguish between fungi attacking the seed reserves and those attacking the embryo. On the other hand work on cereal seed contaminants has shown that these can be destructive when the seed coat is damaged [7], [9]. Our own experiments indicate that similar consequences follow even slight damage to the seed coat of pine seeds, giving a possible explanation of germination failure associated with mechanical de-winging [6], [8]. It is clear that care in the handling of pine seeds will be amply repaid in reducing losses brought about by a weakening of the seed coat.

SUMMARY

Losses of seeds of *Pinus patula* associated with damage to the seed coat have been shown to be due to invasion of the seed tissues by saprophytic seed-borne fungi. Seed destruction appears to depend largely on growth rate and resistance to destruction increases as the seedling germinates. It is suggested that germination losses in pine seeds following mechanical de-winging may be due to fungal invasion facilitated by minute damage incurred in the process. Care is recommended in handling of pine seeds to prevent this type of loss.

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REVIEW

THE EIGHTH PLAGUE, by D. Rhodes. Published by Longmans, Green, London. Price 13s. 6d.

This is a novel, an exciting novel, with thrills and spills, political intrigue and counter-move, and everything that goes to make a good story. The background is the fight against the desert locust, and behind the fiction there is a fascinating account of locust control from the air. The scene is East Africa, but the author has been careful not to name the territory and to portray imaginary characters. Since no offence can be taken, he has been able to give full scope to his imagination in describing political intrigue in a mythical Senate. As a story the book is well worth reading, but in addition it provides a pen-picture of the hazards and frustrations of locust control.

THE PROTEIN COMPOSITION OF SOME EAST AFRICAN SEEDS

By L. Fowden and Miriam Wolfe, Department of Botany, University College, London

(*Received for publication on 28th December, 1956*)

In 1953 Professor Pearsall visited selected areas of East Africa, under the auspices of the Nuffield Foundation, to assess the importance of ecological factors on crop yields and quality. The present investigation, in which the complete composition of the proteins of certain common seeds grown in East Africa is determined, is a further development arising from this visit; as such, it was supported by a grant from the Nuffield Foundation, to whom we wish to express our sincere thanks.

Our analyses are confined to seeds of cotton, sunflower and maize several different varieties of the latter being examined. Whilst we are aware that the literature contains many reports of the protein composition of these types of seed, especially of maize, the data presented has usually been either incomplete or subject to high experimental errors. We have determined complete amino acid compositions using methods designed to eliminate or markedly reduce certain major sources of error commonly encountered in much of the work on the proteins of seeds. The determination of complete amino acid compositions of seed proteins is, of course, desirable for purposes of comparative biochemistry; if, in addition, such analyses show that the total nitrogen present in individual amino acids accounts for all the protein-nitrogen, then the amino acid assays themselves are unlikely to be subject to large errors. No such check is possible when the contents of only a few amino acids are determined.

Undoubtedly the largest sources of error in the determination of the composition of seed proteins arise during the preliminary hydrolysis of the protein to its constituent amino acids by mineral acid solutions. In the past, this hydrolysis has usually been carried out directly upon the finely ground seed, in which protein represents only 10–30 per cent of the seed dry weight, whereas carbohydrate may be present in cereals in amounts as high as 80 per cent. Appreciable destruction of some amino acids then occurs, for it is a well-established fact that the presence of considerable amounts of carbohydrates during the acid hydrolysis of proteins leads to the formation of much humin (an insoluble nitrogen-containing compound) and to marked losses of amino-nitrogen. The aromatic, basic and sulphur-containing amino acids are most susceptible to destruction in this way. Many of the essential amino acids fall into these categories, so that values reported earlier for the amounts of these amino acids in proteins must be regarded, in many instances, as being too low. A further objection to the use of ground whole seeds is that the proteins present in the meal are less readily soluble in mineral acid than are purified proteins and so hyrdolysis to amino acids may be incomplete.

To overcome these types of error arising during the hydrolysis we have prepared purified protein fractions from the seeds by the use of suitable extraction procedures; generally these fractions contained about 80 per cent protein and could be hydrolysed without humin formation. The extraction procedure used varied slightly for different seeds, but always satisfied one essential condition—it yielded a protein fraction entirely representative of the total protein of the seeds, i.e. virtually 100 per cent of the nitrogen of the original seed was present in the final purified preparation.

Previous investigations have shown that both the total protein contents and the composition of the proteins may vary in different varieties of maize seeds (Frey, 1949, 1951). The variations encountered in protein composition have usually been attributed to the fact that the individual protein, zein, tends to form a higher percentage of the total protein in those seed types having relatively high protein levels. Relative to most other proteins, zein is a protein that is markedly deficient in certain amino acids, particularly lysine, tryptophan and valine. Thus in high-protein maize seeds, these three amino acids would be expected to represent smaller percentages of the total protein than they do in the protein of seeds having low total protein contents. Previous work has tended to confirm these suppositions (*see* Sauberlich *et al.*, 1953). The results of our analyses, however, indicate that the protein composition of different maize varieties can be significantly different although their total protein contents are fairly uniform, i.e. differences of protein composition cannot be entirely attributed to variations in the proportions of zein present in the total protein.

MATERIALS AND METHODS

The Seeds Analysed.—All the seeds analysed were of varieties commonly grown in East Africa. The batches of seed used were dispatched to us by courtesy of Sir Joseph B. Hutchinson, F.R.S., after they had been harvested from plots at the Cotton Research Station, Namulonge, Kampala, Uganda. All seeds were grown on a dark-brown clay loam of high fertility. The cotton seeds were East African acclimatized stock (variety number BP.52) of American Upland cotton and the sunflower seeds were from Uganda acclimatized stock. Seven varieties of maize were examined. They represented three main varieties: K.8, Ulu and Muratha. K.8 and Muratha are basically white-grained varieties, whilst Ulu is yellow-grained. Maize, however, is naturally out-pollinated and off-type colours can occur; red and yellow grains, together with white, are often found together on the same cobs of the K.8 variety, due to the direct pollination of the mother cobs with foreign pollen. The K.8 white, K.8 red and K.8 yellow seed samples analysed were obtained from cobs having grains of such mixed colours. In the Muratha variety, some yellow-grained cobs resulted by partial segregation from an earlier outcross with yellow-grained maize. The yellow and white Muratha seeds analysed therefore came from different cobs. The two samples of Ulu maize were of dent and flint types and so differed in grain-shape and hardness characteristics, which are inherited independently of grain colour. Although every gradation exists between flint and dent grain-types, the samples of Muratha seeds used were largely dent, whilst those of K.8 were mixed.

Isolation and Purification of Seed Proteins.—The sunflower seeds were dehulled and the cotton seeds largely stripped of seed hairs before use. The sunflower seeds were then crushed in a mortar and thoroughly mixed with the first extracting liquid, 99 per cent iso-propyl alcohol. The maize and cotton seeds were ground in a mill to pass through a 40-mesh seive and the meals that resulted were used for protein extraction.

The meals (maize, cotton and sunflower) were first extracted for two 24-hour periods with 99 per cent iso-propyl alcohol, in order to remove fatty substances. Portions of the dried residues were then extracted by a method slightly modified from that of Foster, Yang and Yui (1950), which brought over 96 per cent of the total seed nitrogen into solution. In the cases of maize and cotton seed meals the method used was as follows. Samples (approximately 5 g.) of the fat-free meals were shaken for five 48-hour periods with 25 ml. of the pH 10–11 borate buffer of M/20 concentration which contained 1 per cent of the detergent, Teepol 530 (supplied by Shell Chemicals Ltd.) and 0.2 per cent sodium bisulphite. The five extracts from each sample were then pooled. Sunflower seed samples were extracted for five 48-hour periods with, alternatively, the borate buffer solution above, and 10 per cent sodium chloride solution. Micro-Kjeldahl assays indicated that 98–99 per cent of the total seed nitrogen of cotton and maize was extracted and 96–98 per cent of that of sunflower.

In order to isolate the protein components of these extracts, the pH of each was adjusted to that of the isoelectric point of most proteins (pH 4.0–4.5) by careful addition of trichloracetic acid. Protein precipitation was completed by warming the extracts to 50°–60° C. for 30 minutes. The protein was then collected by centrifugation and purified by washing repeatedly with hot water and hot 5 per cent trichloracetic acid solution (ethanol could not be used because some seed proteins, particularly zein, are soluble in it). The residues were finally rinsed in ether and dried at room temperature. Nitrogen contents of the residues were again determined by the Micro-Kjeldahl method. The protein fractions finally obtained accounted for over 96 per cent of the nitrogen present in the extracts. These fractions were thus representative of the total seed proteins. The nitrogen determinations also indicated that the amounts of nitrogen-containing compounds, other than proteins, present in the seeds were small.

Protein Hydrolysis.—The acid used for protein hydrolysis consisted of a mixture of equal volumes of 10 N. hydrochloric acid and glacial acetic acid in which 1 per cent stannous chloride was present. Hydrolysis mixtures (1 ml. of acid for each 3 mg. of protein sample) were placed in sealed ampoules in an oven at 100° C. The optimum period of hydrolysis, as judged by the yield of α-amino nitrogen, was in all cases about 18 hours, so this time was consistently used. No humin formation was noticeable under these conditions. The hydrolysates were then evaporated to dryness *in vacuo* at 50°–60° C. and the process was twice repeated, after additions of small quantities of water, in order to remove all traces of free acid. The final residues of amino acids were dissolved in water to give solutions containing 0.45–0.90 mg. of α-amino nitrogen per ml.

Assay of total α-amino nitrogen was made by the method of Yemm and Cocking (1955).

Assay of Individual Amino Acids.—Amino acids present in the hydrolysates were estimated, after they had been separated on paper chromatograms, by the method of Fowden (1951) using the subsequent modifications and solvents described by Wolfe (1957). 0.1 ml. portions of the solutions resulting from hydrolysis (*see* above) were used for each chromatogram. All estimates were made in triplicate and were based on the recovery values obtained when known amounts of each amino acid were run on standard chromatograms under identical conditions. The standard errors of the means of the determinations have been calculated and, although they are not presented in this paper, they show that the probable error of any amino acid value quoted later is not more than ±5 per cent of the stated value.

Tryptophan was estimated directly on the protein fractions by a specific colorimetric method using Erlich's reagent (p-dimethylaminobenzaldehyde).

Amide-nitrogen in the samples was estimated by the Nessler colorimetric method, after its release as ammonia by hydrolysis with N. HCl for three hours at 100° C.

RESULTS

The protein contents of the seven varities of maize seed analysed were closely similar and fell in the range 8.2–10.3 per cent by weight of the finely-ground seeds (*see* Table I). They may all be considered as varieties of moderate protein content, for these values are about the middle of the range of values found for maize seeds of very low and very high protein contents (4.9–18.4 per cent of the dry weight) that have been examined (Frey, 1951). Cotton and sunflower seeds had higher protein contents than the cereals. When making comparisons of the different seeds, it should be remembered that the sunflower seeds were dehulled before analysis, and so the higher protein content may in part be due to the removal of a relatively protein-poor testa.

TABLE I

The nitrogen and protein contents of the finely-ground seeds and of the purified protein fractions isolated from the seeds.

(The nitrogen determinations were made by Micro-Kjeldahl procedure; protein contents are calculated by multiplying total nitrogen values by 6.25.)

Type of seed	Nitrogen content of dry seed g. per 100g.	Protein content of dry seed g. per 100g.	Nitrogen content of isolated protein g. per 100g.	Per cent purity of isolated protein
Sunflower ..	5·61	35·1	14·73	91·1
Cotton ..	3·76	23·6	11·92	74·5
Maize, K8 red..	1·65	10·3	12·50	78·1
Maize, K8 yellow ..	1·32	8·2	12·76	79·8
Maize, K8 white ..	1·53	9·6	12·73	79·6
Maize, Ulu flint	1·60	10·0	12·26	76·6
Maize, Ulu dent	1·59	9·9	12·80	80·0
Maize, Muratha white ..	1·46	9·1	13·34	83·4
Maize, Muratha yellow ..	1·54	9·6	12·73	79·6

Contrary to expectation, the largest differences of total nitrogen and protein contents of the different maize varieties do not occur between samples of the three main types, but between the three colour-types of K.8 seed. Since these seeds had all come from the same cobs, different nitrogen and protein contents are hardly likely to have arisen due to differences in the supply of nutrients to the developing seeds and must therefore, presumably, represent true biochemical differences of genetic origin.

Table I also shows the nitrogen and calculated protein contents of the protein fractions isolated from the seeds. The extraction procedure, whilst not leading to critically pure proteins, did yield samples where the average protein content was about 80 per cent. Thus, in the case of maize seeds, impurities (substances other than proteins) present at a level of about 90 per cent in the original seeds, were reduced to about 20 per cent in samples finally hydrolysed.

Table II shows the amino acid composition of the different protein factions; all values are expressed on a nitrogen basis, the nitrogen present in each amino acid being calculated as a percentage of the total protein-nitrogen. This method of presentation is considered most suitable for comparative protein studies (*see*

Tristram, 1949), and also has the advantage that, for any one protein, a check on the completeness of the recovery of protein-nitrogen may be obtained by summation of the individual amino acid and amide values. Since the recoveries obtained are between 96–103 per cent (*see* Table II), the amino acid values presented are considered to be free from any large systematic errors.

In order that these determinations may be more generally useful, particularly in their possible application to nutritional problems, we have recalculated the values for the amino acids now considered essential for man (Fruton and Simmonds, 1953) and, in Table III, expressed them as g. of each amino acid that would become available upon hydrolysis (by acid or enzymes) of the protein in 1 kg. of each ground seed meal examined. Values for individual amino acids present in cotton or sunflower seeds are now generally much larger than the corresponding values for the maize seeds, due to the much higher total protein contents of the former types of seed.

TABLE II

The amino acid composition of the "bulk" proteins of maize, sunflower and cotton seeds. Data are expressed as g. nitrogen in each amino acid per 100 g. total protein nitrogen.

Amino Acid	Maize K8 red	Maize K8 white	Maize K8 yellow	Maize Ulu dent	Maize Ulu flint	Maize Muratha white	Maize Muratha yellow	Sun-flower	Cotton
Alanine	6·0	6·0	5·3	6·5	7·3	7·5	7·5	3·4	4·2
Arginine	8·7	8·5	8·5	14·7	14·7	13·1	13·7	16·7	17·0
Aspartic acid	3·2	3·8	5·5	4·0	4·0	3·7	4·1	5·3	5·0
Cyst(e)ine	2·3	2·7	2·7	1·8	2·1	2·2	3·0	1·2	1·7
Glutamic acid	8·3	8·2	9·5	9·4	8·9	7·9	7·5	9·3	6·8
Glycine	2·7	3·3	3·5	4·6	4·7	3·9	3·7	5·3	3·9
Histidine	7·8	6·6	7·0	5·9	6·6	4·8	4·9	6·6	6·8
Isoleucine	4·4	4·9	4·0	3·1	2·9	4·4	4·3	5·0	3·5
Leucine	9·9	9·5	9·2	7·7	6·8	11·0	10·7	5·8	4·9
Lysine	4·5	4·2	5·7	7·1	7·5	4·3	4·2	4·0	10·0
Methionine	2·6	2·8	3·0	3·2	3·2	3·3	3·2	2·1	3·2
Phenylalanine	5·6	5·1	4·3	3·5	3·5	4·0	3·9	4·7	3·6
Proline	4·6	3·3	3·8	5·0	4·8	4·8	4·9	4·6	6·6
Serine	3·2	3·7	4·1	3·6	3·7	3·4	3·6	3·6	5·1
Threonine	6·6	10·8	9·7	6·2	6·5	3·4	2·1	4·2	4·5
Tryptophan	0·77	1·05	0·74	1·04	0·77	0·75	0·72	1·48	0·84
Tyrosine	2·2	3·2	3·2	2·3	2·2	2·2	2·0	3·9	3·2
Valine	4·6	6·2	5·2	3·0	2·9	4·0	3·9	5·8	4·9
Amide	8·0	4·7	4·7	6·2	5·6	8·6	8·5	10·0	6·6
TOTAL	96·0	98·6	99·6	98·8	98·7	97·3	96·4	103·0	102·3

TABLE III

The amino acid composition of the seeds of maize, sunflower and cotton. Data are expressed as g. of each amino acid resulting when the protein present in 1 kg. of each seed "meal" is hydrolysed. (Only those amino acids now considered essential for man are listed.)

Amino Acid	Maize K8 red	Maize K8 white	Maize K8 yellow	Maize Ulu dent	Maize Ulu flint	Maize Muratha white	Maize Muratha yellow	Sun-flower	Cotton
Isoleucine	6·9	5·7	6·0	4·3	4·7	5·6	6·3	26·5	12.4
Leucine	15·3	13·1	11·7	10·1	11·6	15·0	15·4	30·5	17·4
Lysine	3·9	4·6	2·9	6·2	5·9	3·3	3·4	11·6	19·8
Methionine	4·5	4·9	4·0	5·5	5·4	5·2	5·3	12·8	13·0
Phenylalanine	10·9	7·8	8·0	6·5	6·6	6·8	7·2	31·0	16·0
Threonine	10·3	14·1	13·6	9·8	9·4	4·7	3·1	22·1	16·0
Tryptophan	0·92	0·82	1·0	0·88	1·20	0·79	0·80	5·98	2·29
Valine	6·4	6·6	6·9	3·8	4·8	4·9	5·1	27·1	15·6

DISCUSSION

The value of a seed as a source of dietary protein is dependent upon three main considerations; these are the total amount of protein within the seed, the composition (or quality) of this protein, particularly in regard to the essential amino acids, and the digestibility of the protein. Maize seeds are known to be poor sources of dietary protein, compared to many other types of seeds. In the past this has been regarded as probably being due to the interaction of all the above factors, for, in addition to the low total protein content of the seeds, many earlier workers have concluded that this protein is also of low quality, being relatively deficient in a number of essential amino acids, e.g. tryptophan, valine, lysine and methionine, when compared with other seed proteins. It is interesting to note, however, that it is many of the essential amino acids that are most readily subject to varying degrees of destruction during acid hydrolysis of highly impure protein samples. Thus, since all previous values seem to have been obtained by direct acid tretament of whole ground seeds (where carbohydrates approach 90 per cent of the total seed weight for maize), these values are probably too low. When the values reported in Table II for the essential amino acids in maize protein are compared with those for sunflower and cotton seed proteins, it will be seen that the former are usually as high, and sometimes higher, in particular maize varieties, than the values for the latter proteins. Tryptophan, however, must still be regarded as being relatively deficient in most of the maize varieties studied. The advantages of sunflower or cotton seeds over those of maize as a source of protein would then seem to rest primarily on their higher total protein content and perhaps on their better digestibility properties.

One rather unexpected finding was that fairly large variations of protein composition occurred in the different varieties of maize. Differences of protein composition may be large when intervarietal comparisons (i.e. "K.8's" cf. "Ulu's c.f. "Muratha's") are made, whereas intravarietal comparisons show differences which are not generally significant (*see* Table II). The largest differences are encountered in the values for a number of essential amino acids (lysine, leucine, isoleucine, valine and threonine) and arginine and histidine. The following generalizations may be made:—

1. Ulu maize protein contains less leucine, isoleucine and valine than the proteins of K.8 or Muratha maize varieties; they are also relatively rich in the three basic amino acids.

2. Muratha maize protein has contents of threonine and histidine that are much lower than the corresponding values for K.8 or Ulu seed proteins.

3. Arginine is relatively deficient in the protein of the K.8 varieties compared with its levels in the Ulu and Muratha seed protein.

These variations of protein composition between different commonly-grown East African varieties of maize are of significance in considering the use of the seeds as a source of food. Where recourse to diets containing large proportions of maize is obligatory, it would obviously be more satisfactory to use a mixture of seeds of several named varieties, rather than a single variety, thereby ensuring a more balanced supply of the "essential" amino acids required for the normal growth of man and animals.

A further conclusion of a more fundamental character may also be drawn from these differences. They indicate that many individual proteins, other than zein, occur in maize seeds, and that these proteins are present in different varieties of maize in widely differing proportions. These additional types of protein are likely to include some which differ markedly in amino acid composition.

A more detailed consideration of the composition of the protein of sunflower and cotton seeds reveals that certain amino acids are present in relatively low concentrations compared with those for leaf proteins. In the protein of sunflower seeds alanine, cyst(e)ine and lysine occur in low amounts, whilst in cotton the leucines and tryptophan are relatively deficient. Unlike many seed proteins, which are often somewhat deficient in one or more of the basic amino acids, cotton contains all three in high proportions.

SUMMARY

The amino acid composition of the proteins present in sunflower, cotton and seven different varieties of maize seed have been examined. Proteins present in the seeds were isolated and purified before acid hydrolysis, whereby many of the analytical errors, commonly encountered in earlier analyses of such seed proteins, were either eliminated or markedly reduced.

Sunflower and cotton seeds contain quantities of protein substantially greater than those found in maize seeds. The qualities of the various seed proteins as judged by their contents of "essential" amino acids do not appear to differ greatly. Maize seeds were, however, characterized by uniformly low tryptophan contents.

Marked differences of composition occurred between the proteins of the different varieties of maize examined. These differences were reflected most strongly in the levels of the "essential" amino acids. It is suggested that if maize must form a substantial amount of any diet, it would be wise to utilize a mixture of seeds of different varieties.

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NOTES ON ANIMAL DISEASES

Compiled by the Veterinary Department, Kabete, Kenya

I Redwater and anaplasmosis.
II East Coast fever and related diseases.
III Piroplasmosis and anaplasmosis of animals other than cattle; trypanosomiasis of domesticated animals.
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V Malignant catarrh.
VI Bluetongue.
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FURTHER STUDIES IN BREEDING CASSAVA FOR VIRUS RESISTANCE

By **D. L. Jennings, East African Agriculture and Forestry Research Organization**

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The breeding of cassavas resistant to mosaic and brown-streak viruses was started at Amani in 1937. A preliminary report of the work up to 1946 has been given by Nichols [6], who continued to be responsible for cassava breeding until his accidental death in 1951. This account therefore covers the testing period of much of Nichols's later material.

AMENDMENTS TO THE METHODS DESCRIBED BY NICHOLS

The techniques of pollination and seed propagation described by Nichols are still in use; but the greater numbers of plants being tested, and the necessity to seek a higher level of resistance to mosaic, has led to amendments in the nursery and field-testing techniques. Seedlings are planted in nurseries at Amani in the short rains (October–November); the plots are well isolated from sources of infection, and little disease appears in them. As a rule, two cuttings are taken from each seedling for planting in a field elimination trial during the following short rains. Only those clones that survive this trial without becoming diseased are multiplied in a maintenance plot at Amani, cuttings from the original nursery plant being used for this purpose. At the same time the selected clones are planted in a replicated resistance trial.

Recently, in order to economize in field space, the spacing of plants in field trials has been modified from the system described by Nichols. After experimenting with several methods, we now set two rows of trial plants between hedgerows of diseased plants, 12 ft. apart. Plants are spaced at 5 ft. intervals in the row, and each row is placed 3 ft. from a diseased hedgerow, leaving 6 ft. between the trial rows. The design usually used is a rectangular lattice containing 110 clones in four replicates of three-plant plots. The trials are harvested after ten months, as before, but selections from them are now given a third trial of longer duration. Three control varieties are included in each trial. The moderately resistant cassava hybrid 37244E has been included in all trials; moderately resistant Ceara hybrids, numbers 46106/27 and 4763/16, were later used, and for 1955–56 trials 46106/27 was replaced by the very highly resistant Ceara hybrid 5318/34.

In the 1954–55 trials, attempts were made to make them more severe, so that selection for a higher level of mosaic resistance could be made. This was done by plucking the plants in early April and again in early May. This proved a simple method of causing symptoms of mosaic to appear in infected but hitherto symptom-free plants of resistant varieties. The results of plucking two out of four replicates in each of two trials are given in Table I. Each replicate contained 330 plants.

TABLE I

(*The proportion of plants producing mosaic symptoms in a plucking test*)

	Plucked replicates %	*Unplucked replicates* %
Trial No. 60 ..	68 & 58	39 & 34
Trial No. 61 ..	68 & 65	48 & 44

By this means the incidence of mosaic symptoms in the moderately resistant control varieties was sometimes increased to a very high level. Whereas in earlier trials it was usually not possible to draw a distinction between them and more highly resistant clones, the use of the plucking technique revealed a group of hybrids whose resistance was significantly greater. The treatments were again used with success in 1955–56; it was apparent, however, from both years' results that the efficacy of the treatments was influenced by edaphic factors as yet obscure.

THE ESTIMATION OF MOSAIC RESISTANCE

When field resistance trials were first started they were recorded monthly from the date of planting, and the assessment of resistance was based on the total number of months that the plants remained free from disease. This system has the advantage that it measures differences in the time taken for disease symptoms to appear as well as the total number of plants that produce symptoms. Susceptible varieties produce symptoms very early in the trial; varieties of intermediate resistance remain free for several months and then succumb; while more resistant varieties either remain symptom-free, or a small proportion may show symptoms in the later stages of the trial. The differences revealed between the very susceptible and intermediate classes proved useful for selecting cassava parents for back-crossing with interspecific hybrids; but differences in the time taken for symptoms to appear in more resistant varieties are of no importance, so the method of recording was changed.

Experiments have shown that, in resistant clones, symptoms may be confined to one branch, even though the branch may have been diseased for over a year; cuttings from the symptom-free branches usually produce healthy plants. It is therefore considered that, in a resistant plant, the disease status of each branch is independently determined. Plants under test are scored for resistance only at the end of a trial; and, as there are only a small number of plants of each clone under test, the degree of "contamination" (*see* Cours [1]) is determined for each clone by scoring the proportion of the branches that show symptoms of mosaic, according to the following scale:—

No mosaic symptoms = 0.

Symptoms on one branch only = 1.

Symptoms on more than one branch but less than half the branches = 2.

Symptoms on more than half the branches = 3.

Further, the intensity of the disease is now taken into account. In resistant plants the symptoms may be: (1) a pale, mild chlorosis with no leaf distortion. This is scored 1. (2) A normal yellow chlorosis without leaf distortion. Score 2. (3) Chlorosis and very slight leaf distortion but no reduction in leaf size. Score 3. (4) In less resistant forms, varying degree of leaf distortion and reduction in size occur, culminating in an almost complete loss of functional leaf area in the most susceptible varieties. All these are scored 4. The four classes used are adequate for the purpose of recording resistant varieties; and subdivisions of the fourth class, according to the reduction in leaf size, are not used in routine resistance trials.

The coefficient of correlation between contamination and intensity was found to be 0.48 and 0.43 for the clones included in two adjacent resistance trials. This means that, in these trials, susceptible clones with a high contamination tended to have a relatively intense form of mosaic; while, in resistant clones, the disease tended to be less intense with no reduction in leaf size, and little or no distortion of the leaf. The leaf chlorosis was also frequently less intense. Thus a more accurate assessment of resistance can be obtained if both the contamination and intensity of a clone are considered. The product, per cent contamination × per cent intensity, is a useful value which has been used; but, since many of the 12 combinations of contamination and intensity (four levels of contamination and three of intensity) occur but rarely, the recording can be simplified to the following with little loss of information:—

M1. Only one branch affected with no leaf distortion.

M2. Only one branch affected with leaf distortion.

M3. More than one branch affected but less than half the branches with or without leaf distortion.

M4. More than half the branches affected, with or without leaf distortion.

This gives a maximum score of 48 for complete susceptibility with 12 plants in a resistance trial. The total scores recorded are expressed as a percentage of the maximum to give per cent susceptibility, and the per cent resistance of a clone is then obtained by subtracting this figure from 100. The relative efficiency of the several methods can be assessed by comparing the variance ratios when trials are recorded by each method; results for two trials treated in this way are given in Table II.

TABLE II

Methods of Recording	Trial No. 60		Trial No. 61	
	Variance Ratio	Relative Efficiency	Variance Ratio	Relative Efficiency
Plants infected	4·87	100	5·77	100
Contamination	6·25	128	6·22	108
%C × %I ..	6·71	138	—	—
M1 to M4 ..	6·56	135	7·94	138

THE ESTIMATION OF BROWN STREAK RESISTANCE

Symptoms of brown streak can be recorded in leaf, stem or root [5]. Under the conditions of these trials, they do not as a rule become evident until the plants are mature, and are not recorded until harvest in August. The necrotic stem symptoms are scored for severity after paring away a thin layer of tissue from the abscission layers remaining after the leaves have been normally shed. Root symptoms are scored in the same way after slicing up the tuber. The intensity of symptoms is variable; they may involve the whole of the starch storage tissues in stem and root in a very susceptible variety, or may take the form of occasional flecks in resistant varieties. A clone in which only a small proportion of plants show symptoms usually has the less intense form of symptoms, while clones which are completely contaminated have more intense forms.

In long-term trials, the symptoms in the stem are best recorded at the end of the first season, as well as at the final recording, since plants may recover in their second season.

Progress in Breeding

Intraspecific Crosses

Manihot esculenta Crantz (Cassava).—Attempts by Nichols to find a mosaic-resistant variety by importing a wide range of material from different parts of Africa and other tropical countries were not successful, most of the imported varieties proving more susceptible than the local varieties. A few possessed some resistance, and when these were crossed together a considerable improvement took place. Successful crosses were made between *Mpezaze* (Madagascar) and *F100* and *F279* (Java), and between *F100* and the local varieties *Mbarika* and *Malindi*. *Butter Stick* (Mauritius) and *C997B* (Gold Coast) also produced successful hybrids, when crossed with the *F1* of the *Mbarika* × *F100* cross. Other varieties, notably *Msitu* (Zanzibar), *Aipin Valenca* (Belgian Congo), *Macaxeira Aipin* (Brazil) and *C756B*(*b*) (Gold Coast), which were not used in intervarietal crosses, possessed a degree of resistance to mosaic that made them superior to local cassavas for crossing with interspecific hybrids. Few of the varieties possessed resistance to brown streak, an exception being *Aipin Valenca*. *Macaxeira Aipin*, though susceptible, contributed factors for brown-streak resistance which were evident in the progeny.

A small number of crosses made between the first generation hybrids of this series did not bring any further advance, and intraspecific hybridization was then discontinued.

Interspecific Crosses

Manihot glaziovii Muell.-Arg. (Ceara Rubber).—This species attracted attention as a possible source of resistance genes because it is extremely rare for a mature tree to show signs of mosaic infection. The incidence of mosaic in young seedlings may be high; but the intensity of symptoms, which is often severe for a time, is later observed to be reduced. Trees near human dwellings are frequently cut back severely, with the result that severe symptoms are again produced in the new growth; but, if the trees are allowed to grow normally again, the symptoms are transient.

The hybrids produced from the cross *M. glaziovii* × cassava, which were vigorous tree-like plants, behaved similarly to the Ceara parent; the plants became infected in field trials but symptoms were mild and frequently transient. In the first back-cross to cassava, improved mosaic resistance was evident and one clone in particular, No. 4032, remained free from both mosaic and brown streak when tested in a field trial and by grafting. Hybrids from subsequent back-crosses proved to be the most promising agronomically, and nearly all the hybrids at present being distributed belong to this group.

Good yields were reported for clones of the second back-cross generation, which were distributed to the Departments of Agriculture for trial ([3] and [4]). These hybrids were cassava-like in habit, and produced large tuberous roots of somewhat variable quality. Selected hybrids from a third back-cross showed improved agronomic qualities, and were distributed to native growers from several centres. Notable among these are hybrid numbers 46106/27, 4763/16 and 4697/4, which are proving successful in several coastal areas. The strike from cuttings is better than for diseased native varieties, yields are in general much higher, and the palatability of the roots is good. From the point of view of virus resistance, however, the results are not as good as was first thought; resistance is not high enough for the very severe conditions occasionally encountered.

In breeding these clones, selection has taken place under moderately severe conditions, where little or no distinction could be made between the resistance of the interspecific hybrids selected and that of the true cassava hybrids used as back-cross parents. Hence, it was not possible to determine whether a clone owed its resistance to true cassava genes or to genes of *M. glaziovii* origin. Probably, in most cases, a combination of genes from both sources was present; different genes were probably present in the three different lines of hybrids descended from the three first back-cross clones used as parents for the second back-cross, and also in the sub-lines descended from the several second back-cross clones later used as parents. This hypothesis was put to the test in 1953 and 1954, when crosses between these different lines were made to see if the genes could be regrouped with favourable results.

The field testing of these clones coincided with the first use of the plucking technique in field trials; in some of the trials this succeeded in simulating the very severe conditions encountered elsewhere. Table III gives the results of two replicated resistance trials, in which intercrossed hybrids were tested without the usual preliminary elimination trial. Trial numbers 60 and 61 were carried out on adjacent plots in the 1954/55 season and trial numbers 67 and 68 on adjacent plots in the 1955/56 season. Mosaic was particularly severe in trial number 60 and to a lesser extent in trial number 67, but the resistance of a good proportion of the progeny enabled them to withstand these conditions. The severity of trial numbers 61 and 68, as revealed by the slightly lower incidence of mosaic in the moderately resistant control varieties, was not so high, and resulted in a higher proportion of clones being placed in the very resistant classes.

TABLE III

Per cent Resistance	Number of Hybrids			
	Trial No. 60	Trial No. 61	Trial No. 67	Trial No. 68
100	7	8	21	25
90–99	12	13	24	25
80–89	18	13	18	15
70–79	16	13	16	7
60–69	10	13	16	9
50–59	6	9	2	10
40–49	8	9	6	8
30–39	9	10	0	2
20–29	9	5	2	3
10–19	5	7	2	2
0–9	7	7	0	1
Control Varieties	Per cent Resistance			
37244E	50	78	77	83
46106/27 ..	59	73	—	—
4763/16 ..	61	90	71	85
5318/34 ..	—	—	97	100

The selected clones are being further tested in several localities, and it will be some time before their true resistance under a variety of conditions is known.

First consideration was given to resistance to mosaic disease when hybrids were chosen as parents for further breeding, and, in consequence, not all the parents used have possessed resistance to brown streak as well. In the third and fourth back-crosses, Ceara hybrids resistant to both diseases were obtained and the resistance of some hybrids to brown streak, though short of immunity, appeared to be adequate for all the areas in which the clones were tested.

M. dichotoma Ule (Jaquie Manicoba Rubber).—Attempts by Nichols to study the virus resistance of *M. dichotoma* by conducting grafting tests on cuttings taken from the original trees met with little success, since the species is extremely difficult to propagate vegetatively. Only one cutting from one tree was successfully established and this was found to be susceptible to mosaic. In grafting tests on the F1, 21 out of 22 plants failed to produce symptoms of mosaic, even though the grafted plants were observed for a period of nine months. Among a group of eight of these hybrids, retested in the the field, only one produced growth of normal vigour; the others remained stunted and not more than four or five feet high, even after several years' growth. The fact that they remained free of disease symptoms is of limited significance because of the weak growth. Cuttings from the one hybrid that did show vigour, derived from a cross using a different *M. dichotoma* tree, later produced symptoms of mosaic when subjected to a severe field test that included plucking treatment.

Because of the poor seed setting of the F1 clones, most of the material tested from the second generation was from open-pollinated seed. Several generations of back-crossing were then carried out. None of the third generation plants selected showed any promise of yield, the roots being mostly wood and fibre. A considerable improvement in this respect occurred in the two subsequent back-crosses but yields were still low. The few clones distributed for further trial by the Departments of Agriculture were found to be inferior to the Ceara hybrids and were later discarded.

A relatively high proportion of the clones from the back-crosses were placed in the resistant classes, but, as with the Ceara hybrids, resistance was not high enough. Many hybrids were slow in striking from cuttings and were relatively susceptible under poor growing conditions. Intercrosses between the several lines of *M. dichotoma* hybrids and between fourth-generation *M. dichotoma* hybrids and third back-cross *M. glaziovii* hybrids were made in 1953 and 1954; and, although testing is incomplete, the indications are that hybrids from the latter group of intercrosses possess very high resistance; yields also are more promising.

As with the Ceara hybrids, first consideration was given to mosaic resistance when selecting hybrids for further breeding, with the result that, although the early generations showed very good resistance to brown streak, most of the F3 and F4 hybrids were susceptible.

"Tree Cassava."—Cuttings from a specimen of "Tree Cassava" did not show signs of mosaic infection when tested in a field trial of moderate severity; but cuttings were later infected experimentally in a greenhouse test. Resistance to mosaic was not particularly marked in the F1 nor in the first back-cross to cassava. The behaviour of hybrids in the second and third back-cross generations follows closely that of the Ceara series of the same generation, but they are inferior to the best of the Ceara selections both from the point of view of resistance to virus disease and agronomic characteristics. A series of intercrosses between "Tree Cassava" and Ceara hybrids was raised, but, with the exception of a few clones, resistance was not good.

M. catingea Ule.—*M. catingea* is a tree species in many ways similar to *M. glaziovii.* A cutting from a tree was infected with mosaic in a greenhouse test. Since the tree did not flower until 1946, progress with this species is well behind that of the others. The F1 hybrids, like the Ceara F1 hybrids, were tree-like and vigorous, and had woody root systems. Several produced symptoms of mosaic in a field trial, but, as with the Ceara hybrids, these were mild in intensity and often transient. Brown streak resistance was also good. By crossing the F1 hybrids with resistant clones of Ceara and *M. melanobasis* derivation, plants with an improved type of root have been obtained without loss of virus resistance.

M. saxicola Lang.—Work on this species in Java, reported by Bolhuis [2], was handicapped by the toxic nature of the roots caused by high hydrocyanic acid content. In Amani palatable sweet roots were obtained after three generations of crossing with cassava; but, because of the susceptibility to mosaic, very little controlled pollination was attempted. The species is highly resistant to brown streak. Three generations of seed were raised, but, because the male parent of the first generation is not known, the significance of the resistance to mosaic shown by a few members of the third generation is uncertain.

M. melanobasis Muell.—Arg.—This is a low-growing herbaceous shrub with narrowly lobed leaves. Its root is usually fibrous, but large tuberous roots have been obtained from plants that have been left in the ground for long periods. The roots possess a very high protein content, particularly concentrated in the outer layers. The hydrocyanic acid content is also high, but less than in *M. saxicola.* The species is susceptible to mosaic, but highly resistant, possibly immune, to brown streak.

The species crossed readily with cassava and over 100 F1 plants in several families were tested in field trials. They were straggling low-growing plants like their *M. melanobasis* parent, but were extremely vigorous. Nearly all of them remained completely free from brown streak, but only a few showed a very moderate degree of mosaic resistance. Yields of root were high and greater than those usually recorded for the cassava parents of the crosses. The roots were often 3 ft. or more long, thin, and spreading in a horizontal plane. Analysis for protein content showed that the roots contained approximately twice as much protein as their cassava parent. Even so, the level is so low that it is doubtful if the product has any increased nutritional value.

The first back-cross to mosaic-resistant cassava was tested in a season which was very severe for mosaic, with the result that only a small number were selected; some of these were resistant to brown streak and continued to show promise of high yield. Some retained the bitter taste of the first generation, but others were palatable and popular with the African tasters. The most promising hybrids in this series have been obtained by crossing *M. melanobasis* F1 selections with third back-cross Ceara hybrids. These are now under trial.

VARIATION IN THE BEHAVIOUR OF HYBRIDS IN DIFFERENT LOCALITIES

The virus resistance of hybrids has varied from locality to locality, and, in the same locality, from season to season.

The resistance trials described above are carried out at the Kizugu sub-station, in the foothills of the Eastern Usambaras and about

600 ft. above sea level, and, through the courtesy of the Tanganyika Sisal Growers' Association, at the Sisal Research Station, Ngomeni, situated on the coastal plain and also about 600 ft. above sea level. Under these conditions, susceptible varieties succumb completely to mosaic disease during the first four or five months of the trial, i.e. before April. It is unusual for plants of the moderately resistant control varieties to show mosaic symptoms before April; a small proportion usually show their first symptoms during April or May. Similar behaviour has been reported for moderately resistant varieties in tests at Matuga, near Mombasa, Kenya, and at Morogoro, Kilosa and Tanga, in Tanganyika.

Several instances have occurred where nearly all the plants of these varieties succumbed in the early stages of trial. This occurred in trials conducted by us, in collaboration with the Departments of Agriculture, on coastal sands near Mombasa in Kenya, at Bagamoyo in Tanganyika, and also in trials conducted by the Department of Agriculture in Zanzibar [4]. As yet, the more highly resistant intercrossed clones have only been given an extension trial at Bagamoyo, where several of them remained free of disease while all the earlier issues succumbed.

From other areas, e.g. Uganda and certain inland areas of Kenya and Tanganyika, it is reported that the resistance of some clones of the earliest issues from Amani has been maintained. Several varieties and intraspecific cassava hybrids, which showed only intermediate resistance in their Amani trials, have maintained a satisfactory level of resistance in these areas.

PROBLEMS OF VIRUS BEHAVIOUR IN RELATION TO BREEDING AND THE ASSESSMENT OF RESISTANCE

No evidence has been obtained that differences in mosaic virus strains have influenced the results obtained. Many of the conflicting results can, however, be explained by differences in factors that influence the growth of the plants, and hence the chances of diagnosing the presence of virus.

The results of experiments carried out to study the behaviour of the virus in resistant plants will be reported elsewhere. It is concluded that, in resistant plants, virus frequently moves down the stem without producing symptoms, since symptoms of mosaic were observed in the new shoots of cuttings taken from the bases of mature plants that had never shown any visible symptoms of infection; cuttings from the upper parts of such plants usually produced healthy growth. This seems to suggest that field resistance is due to the control of virus activity at the shoot apex so that its downward movement away from the apex is expedited. It is possible that, if a check in the normal growth of cassava occurs, mosaic symptoms appear in infected but symptom-free plants by an automatic slowing of virus movement from the shoot apex, the virus being given time to act in an appropriate environment. Thus, under certain conditions, topping or plucking were found to be effective in causing symptoms to appear in a large proportion of symptom-free plants; the symptoms were frequently transient when normal growth was resumed.

The stage of growth at which the plant becomes diseased has a considerable influence on the behaviour of the virus. If mosaic symptoms appear early in the life of a resistant plant, the chances of recovery are higher than if the symptoms appear at a later stage when growth is slowing down. On the north coast of Tanganyika, cassava planted in the short rains reaches its full size in five to six months, and then ceases growth, sheds most of its leaves and becomes apparently dormant. A high proportion of plants recorded as diseased in the first season are observed to be symptom-free when the second season's growth follows the dormant period. It appears that the virus moves to the bases of the plants during this period, and does not move up again to any extent when growth is resumed.

In the case of brown streak, differences in the resistance shown by hybrids in different areas can normally be related to the altitude and temperatures encountered. For example, a higher incidence and intensity of symptoms is recorded in the same varieties tested at Kizugu than at Mlingano, which does not experience such low night temperatures. Symptoms are more frequently limited to the root than to aerial parts, and localization of symptoms in the root is particularly common when the attack is mild; they may become more intense in the root if unfavourable conditions follow in the second season. Alternatively, both stem and root symptoms may disappear or be reduced if conditions become more favourable to the growth of the plant.

Hybrids derived from *M. melanobasis* differ in their behaviour to both viruses. A much greater proportion of plants produce symptoms of mosaic in their early second season's growth and may produce their first symptoms of infection at this time. Many show good brown-streak resistance in their first season, but succumb sompletely in their second. These hybrids continue to grow slowly long after Ceara hybrids have become dormant. This characteristic appears to favour the activity of the viruses and has proved a serious handicap in working with what is agronomically a most promising group of hybrids.

In view of the results described, it is not possible to state that a clone is very highly resistant or immune to virus infection on the basis of one test. It may be apparently immune, or it may be a symptomless carrier, but only under the conditions prevailing in the test. Even if a clone survives a grafting test, this cannot be taken as immunity under all conditions, since, as with field tests, symptoms only appear in resistant varieties when the growth of the resistant shoot is adjusted, e.g. by frequent cutting back, so that conditions are sufficiently favourable to the virus. It is possible that no clone will be produced that is immune under all conditions. It is probable however that a level of resistance has been obtained such that symptoms, when present, are invariably of such low intensities as to have no influence on yield. Cours [1] presents figures to show that plants having symptom intensities where lesions do not cover more than half of the leaf, and where the leaf is not more than slightly deformed, do not yield less than healthy plants. Experience at Amani agrees with this. A small proportion of the cuttings from such plants may produce plants with mild symptoms; but the rate of recovery in the initial growth of these varieties is so high that few permanently diseased plants result. If the area of clean resistant varieties could be increased the source of infection would decrease, and the chances of maintaining clean stocks of highly resistant, though not immune, cassavas would be greater.

ACKNOWLEDGMENTS

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SUMMARY

Further studies in breeding cassava resistant to virus diseases have shown that cassavas possessing a high degree of resistance to mosaic and brown streak viruses can be obtained but that the manifestation of resistance is influenced by environmental conditions; it is not known whether complete resistance under all conditions can be obtained. The most successful hybrids are those derived from *M. glaziovii* and in this series improved resistance to mosaic virus was obtained when third back-cross hybrids were intercrossed.

Improvements in the method of field experimentation and the estimation of resistance are reported.

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NOTES ON LARVÆ OF THE SATURNIIDÆ (LEPIDOPTERA)

By J. C. M. Gardner, East African Agriculture and Forestry Research Organization

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Larvæ of many species of this family feed on tree foliage and are often sent in for identification by forest officers and others. The larvæ are nearly always preserved in alcohol and even when it is possible to rear the adult (the stage necessary for primary diagnosis) from living larvæ this process may take the better part of a year. A classification of larvæ is obviously needed and this must of course be based on larvæ definitely associated with reared moths in the first instance. A non-technical field key covering the known larvæ in the E.A.A.F.R.O. collection is given below; only mature larvæ are now considered.

All larvæ now discussed pupate in the top two or three inches of the soil, the pupa resting in the split larval skin for three to nine months before the adult emerges. In another division of the family, larvæ of which are not available, pupation is in silken cocoons attached to twigs and branches.

It seems that incidence in the natural forests of East Africa is maintained at tolerability by biological control with special reference to parasites and disease. In plantations the risk is probably greater (*see Nudaurelia rhodina*); in South Africa, *Nudaurelia cytherea,* not definitely recorded from East Africa has taken to introduced pines and has become a serious pest.

The larvæ are large when full grown (up to 3.5 inches); a typical abdominal segment usually with four prominences (tubercles to strong often backwardly directed spines) on each side, two above and two (the lowest often obscure) below the level of the spiracle; sometimes however there is no definite prominence and this is represented by a group of hairs; the five pairs of abdominal prolegs have several hairs on the outer face and their crochets are of two alternate sizes arranged in a nearly straight line. Larvæ may have quite conspicuous hairs (setæ) but are not densely hairy. In some species very small but conspicuous smooth and variously coloured platelets (each with a minute seta) are present (fig. 1); these are often so closely spaced as to form a mosaic but they may be rather widely scattered. For brevity the three thoracic segments are referred to as T1, T2, T3 and the abdominal segments as A1 to A10; segment A8 bears the last pair of spiracles.

Associated reared moths were identified by Mr. E. C. G. Pinhey, the author of a valuable study of the family (1956. The Emperor Moths of Eastern Africa *J. East Afr. Nat. Hist. Soc.* 23: 1–62 ill.)

Structural characters in the key are given preference since colour may be variable in a species and alters after death.

Dr. P. R. Hesse made the diagrams.

FIELD KEY TO LARVÆ

1. Typical body segments without tubercles or spines, not bilobed above. (Ground colour black partly concealed by dense platelets.) . . . . 2.

   Typical body segments dorsally with paired projections, small tubercles to strong spines, sometimes bilobed. (With or without platelets.) . . . . 3.

2. Body hairs about half as long as width of body. Dorsal black patch on typical abdominal segments more extensive, not triangular (fig. 1) . . . . . *Cirina forda.*

   Body hairs shorter than half body width. Black patch on typical body segments smaller, more triangular (fig. 2) *Nudaurelia rhodina.*

3. Upper surface of segment A8 raised into a fleshy more or less triangular prominence which at its base occupies most of the width of the segment; at the apex a pair of rudimentary to distinct points. (Body green in life.) . . . . 4.

   The upper surface of A8 not swollen above, either with a pair of separate spines or tubercles or these are fused at base which is corneous, abrupt and much narrower (figs. 3, 5) . . . . 6.

4. Typical body segments above roundly bilobed, each lobe fleshy with a minute apical point. The margin of anal plate without small tubercles on disk, the margin with close subequal rounded tubercles . . . . ? *Lobobunaea tyrrhena.*

Dorsal tubercles more abrupt, each with a silver or gold streak externally. Anal plate with a few blackish and very distinct tubercles, two on the disk . . . 5.

5. Dorsal paired projections finely acute. Setiferous tubercles on prolegs coarse, blackish. A black streak across anterior margin of T1 . . . . . . *Gynanisa maia.*

Dorsal projections not acute. Setiferous tubercles on prolegs inconspicuous. T1 with no black streak. *Nudaurelia arata.*

6. Body without distinct platelets . . . . . . 7.

Body with dense to scattered but numerous platelets . . . . 11.

7. Paired dorsal body tubercles very small, blunt. Body skin with numerous pale scattered hairs in addition to those on the tubercles. (Black with a red dorsal stripe posteriorly on typical segments.) *Usta terpsichore.*

Spines acute. Body skin with at most very few hairs . . . . 8.

8. The dorsal pair of spines on A8 separate *Imbrasia epimethea.*

Dorsal pair of spines on A8 fused at base . . . . 9.

9. Spines with several conspicuous and rather stiff pale setæ . . . . . *Nudaurelia dione.*

Spines with only extremely short setæ . 10.

10. Spines very large, the dorsal pair on T2 much longer than those just lateral to them. The fused spines on A8 forming an elongate bifid projection (fig. 5) *Bunaea alcinœ*

Spines acute but much shorter, the four dorsal spines in a row on T2 nearly equal. The partially fused spines on A8 not much higher than wide *Nudaurelia oubie.*

11. Dorsal pair of spines on A8 separate *Nudaurelia tyrrhea.*

Dorsal pair of spines on A8 fused at base . . . . 12.

12. Platelets on body numerous but widely scattered . . . . . . *Athletes steindachneri.*

Platelets densely arranged . . . . 13.

13. The fused bases of the two dorsal spines on A8 wider than high (fig. 6) . . . . . . 14.

The fused bases of spines on A8 higher than wide (fig. 5) . . . . 15.

14. Dorsal spines moderately long, a pair separated by a space about three times the length of a spine. Spines with conspicuous stiff setæ . . *Nudaurelia krucki.*

Dorsal spines very short, each much shorter than one-third of the space between a pair. Setæ fine, not conspicuous *Nudaurelia cytherea.*

15. Spines longer, those of the dorsal pair (e.g. on A7) longer than the space between them at their bases . *Nudaurelia belina.*

Dorsal spines rather shorter, each not longer than the space between a pair *Nudaurelia gueinzii.**

NOTES ON LARVÆ

Athletes steindachneri Rbl. Pale green, rather darker beneath. Spines orange, with silver at bases of the dorsal spines more evident in some specimens. Head, T1 and anal plate sordid brown. Larvæ on *Acacia xanthophlœa.* Tanganyika: Lushoto.

Bunaea alcinœ Stoll. Black, with orange spots enclosing spiracles; spines very large, black on T2, T3, ivory or orange on A1 to A9. On young plants. *Sapium ellipticum, Khaya anthotheca.* Uganda. Pinhey gives *Cussonia* and *Ekebergia;* widespread.

Cirina forda Westw. Ground colour black, partly concealed by a close mosaic of (? yellow) platelets; without tubercles but with long fine hairs arising from the skin in their place. Heavily defoliated *Erythrophleum guineense,* Kenya: Kwale in late 1954. Pinhey gives *Cussonia; Warburgia;* widespread.

Gynanisa maia Klug. Ground colour green with numerous but widely scattered yellow platelets. Dorsal spines shining silver externally. Spiracles black. Life cycle at Muguga five months. On *Acacia mollissima;* Kenya: Muguga. Widespread.

Imbrasia epimethea Drury. Ground colour black; head, T1, dorsal spines and anal plate reddish; irregular pale yellow spots at spiracle level. In great numbers on *Acacia lahai,* Kenya: Londiani, August, 1951. Widespread.

?*Lobobunæa tyrrhena* Westw. A preserved larva sent as from *Eucalyptus gomphocephala,*

**Nudaurelia conradsi,* judging from exuviæ probably runs to here.

Tanganyika closely resembles the coloured figure given by Fawcett (1903). *Trans. zool. Soc. 17*, 171, pl. 6, fig. 33. Pale green above, darker beneath. The penultimate instar is said to have silver spots and to feed on *Celtis* in S. Africa.

Nudaurelia arata Westw. Ground colour pale green, the dorsal tubercles golden externally; a small golden spot between those and the spiracles. Larvæ on *Piptadenia buchanani*, Kenya: Karura.

Nudaurelia belina Westw. Ground colour black, spines reddish. Pale platelets very close in part. On *Terminalia velutina*. Uganda: Budongo.

Nudaurelia cytherea capensis Stoll. Ground colour deep maroon with close platelets coloured in bands of blue, green, yellow, green, blue on each segment. Body spines short but acute. Preserved larvæ were donated by the Forest Research Officer, Stellenbosch, Cape Province, S. Africa. This is an example of an insect, with several native food plants (Rhus, Euclea, etc.), which readily attacks certain introduced species such as *Acacia, Eucalyptus, Cupressus* and is in fact a serious pest on *Pinus* spp. in South Africa. A full account is given by Tooke (1941. The Pine Tree Emperor Moth. *Dept. Agric. For. Science Bull.* 210, Un. S. Africa). There is no definite evidence of its existence in East Africa but should any larva be found here appearing to run to this species immediate diagnosis and if confirmed, early control measures will be necessary.

Nudaurelia conradsi Rbl. Ground colour black except head, anal plate and prolegs which are red. Platelets almost white. Fused spines on dorsum of A8 with long bifurcations subequal to stalk which is itself rather longer than wide. An adult was reared from a larva found on *Eucalyptus ficifolia*. Kenya: Kaptagat.

Nudaurelia dione F. Ground colour black; spines pale yellowish green, strong and acute with several conspicuous stiff setæ. Dorsomedian spines on A8 with long stalk and short bifurcation. Larvæ on *Chlorophora excelsa;* completely defoliating saplings of *Khaya* sp. Uganda: Mbale; Zirimiti. Also known from Kenya: Kitale.

Nudaurelia gueinzii Karsch. Ground colour black but skin between body segments red. Spines fine, acute, black with white hairs. Platelets pale yellow. On *Schinus molle*; *Eucalyptus* spp.; *Prunus cerasus; Khaya grandifoliola* (transplants). Kenya: Nairobi, Muguga. Uganda: Opit. Pupal period about three months.

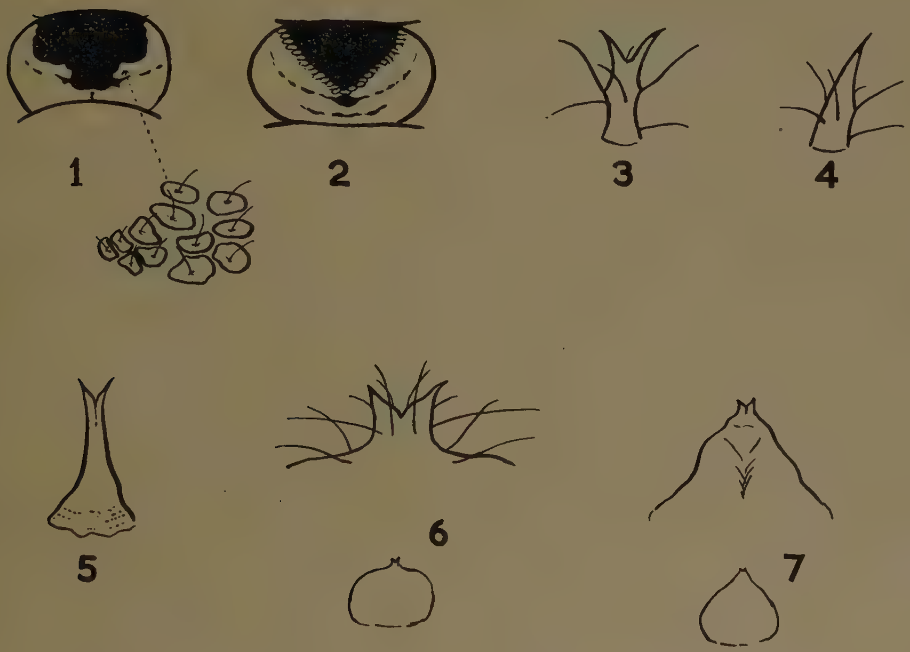
Nudaurelia krucki Her. Ground colour black; spiracles ochreous; platelets pale green-yellow, spines black. On *Schinus molle; Eucalyptus citriodora*, young growth. Pupal period two to three months. Parasite: *Carcelia evolans judicabilis* Mesn. (Tachinidæ). Kenya: Nairobi; Kitale.

Nudaurelia rhodina Roths. Black, spiracles red, very closely covered with pale platelets leaving a triangular black space on typical segments (Fig. 2). There are no spines or tubercles, these represented by groups of rather short white hairs. On *Juniperus procera*. Kenya: Londiani and Thomson's Falls forest divisions. Two cases of severe defoliation of small plantations of juniper are known: *Case* 1. In November–December, 1951, C. Plumb, of the Kenya Forest Department, reported severe defoliation of about 21 acres of plantation trees about 18 feet high at Kerisoi. Moths reared from larvæ sent to E.A.A.F.R.O. duly emerged after a pupal period of about five months. There has been no report since then; no defoliation was noticeable in 1954. *Case* 2. In October, 1954, the Divisional Forest Officer, Thomson's Falls (J. Smart), reported almost complete defoliation of young juniper in a 2-acre plantation at Ol Bolossat. Specimen larvæ were determined at E.A.A.F.R.O. by comparison with those of case 1. About 200 living larvæ were sent to this office but about one-half of these died after becoming discoloured and flaccid; the remainder pupated but only three adults were reared. On inquiry, Mr. Smart replied that "virtually all the larvæ are now (2nd November) dead, both on trees and on ground". No parasites were reared. It appears that an effective natural control exists in the form of a virus or bacterial disease. One of the factors favourable to the spread of these diseases is close aggregation of host larvæ: further observation may show that the disease comes into force in cycles, say of three or four years, when the host larvæ have had time to build up a high incidence.

Nudaurelia oubie Guer. Ground colour black except intersegmental skin and spiracles internally, ochreous. Skin granulate, anal plate with marginal points. One larvæ determined by comparison with a specimen in the Coryndon Museum; found on grass at Muguga. Widespread. Pinhey gives *Euclea* as a host.

Nudaurelia tyrrhea Cr. Black but prolegs, spines and anal plate red. Platelets pale yellow, some pale blue. Kenya: Thomson's Falls; N. Kinangop; Menengai.

Usta terpsichore M. & W. Black, each segment with an orange-red dorsal band reaching to below the level of the spiracles where there are a few irregular spots of the same colour; the anal plate, T1 and external plates on prolegs bronze. The body skin with numerous scattered pale hairs (apart from those on the tubercles). Kenya: Kampi ya Moto. On *Schinus molle*. Pupal period four to five months.



1.—*Cirina forda*, pattern on an abdominal segment (setæ omitted) also platelets enlarged.

2.—*Nudaurelia rhodina*, pattern on abdominal segment.

3.—*Nudaurelia gueinzii*, medio-dorsal spine on A8.

4.—The same, a paradorsal spine on A7.

5.—*Bunaea alcinœ*, medio-dorsal spine on A8.

6.—*Nudaurelia krucki*, medio-dorsal spine on A8 (*below*, showing transverse section through A8).

7.—*Nudaurelia arata*, dorsal prominence on A8 (*below*, outline of segment A8).

NOTES ON OEMIDA GAHANI DISTANT (CERAMBYCIDÆ) PART II

By J. C. M. Gardner, East African Agriculture and Forestry Research Organization and J. O. Evans,* Kenya Forest Department

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This second interim report on *Oemida gahani* should be read in conjunction with the first (Gardner, Evans and Pudden, 1953, *E. Afr. agric. J. 18,* 176–183).

Our plans from October, 1953, were seriously interfered with by Emergency conditions causing restriction of movement in the forests and shortage of labour. Evans, responsible for nearly all the field work now referred to, was called upon to give a considerable proportion of his time to police duties; he was assisted by one African forest ranger.

Evans set up a small field station at Mukutano, well suited for Oemida studies, and an insectary, with a much wider scope, was built at Muguga, the headquarters of E.A.A.F.R.O.

In 1950, a general Survey of East African Forest Insects was started and later four African collectors, two in Uganda, two in Tanganyika, assisted. In addition to other aspects, attention was given to the insect fauna of dead wood in the forests and many samples were caged in the insectary for rearing.

Oemida gahani, it may be recalled, is a longhorn beetle with the habit of breeding in dead wood; its economic importance lies in that the larvæ can tunnel (*a*) in the inner wood (here regarded as "dead") of healthy cypress and juniper trees, having obtained access through external wounds and (*b*) in dry structural timber, with special reference to *Podocarpus* so far, although it is probable that cypress and pine will prove as susceptible when they are used in the future for structural purposes. The first aspect requires long-term research with a view to devising control measures; the second seems simpler with chemical treatments the answer.

SPECIES ALLIED TO OEMIDA

Oemida belongs to the tribe Oemini in the subfamily Cerambycinæ. Since the commencement of the survey 37 species of the tribe Oemini have been reared; of these no less than 14 are almost certainly new species. All have the habit, as larvæ, of feeding in dead wood, and, with one or two possible exceptions, do not normally have to feed under bark to commence with, thus differing from certain other groups of the family.

Since our first report another species of Oemida, *O. impunctipennis* Duffy has been described. This, which is easily distinguished from *O. gahani* in that the elytra are impunctuate, we have from dry *Celtis zenkeri* in Uganda and from a dry climber at Muguga This and most of the Oemini seem to be of little economic importance. An exception is *Androeme plagiata* Aur. a species we have so far only recorded from the West Usambara Mountains in Tanganyika. The first report was from the Silviculturist Tanganyika, who sent in part of a log of *Juniperus procera* with borer tunnels resembling those of *O. gahani* and from which identifiable fragments of an Androeme bettle were recovered; a high proportion of logs was infected. Later, Insect Ranger Elias, on insect survey work in the same locality, sent adults from dead wood of *Juniperus, Podocarpus, Cupressus* and unidentified hardwoods. We found the species to be common in dead wood on our visit to the area in 1955. Adults and larvæ were recovered from an apparently healthy juniper except that emergence holes were present in old unoccluded pruning scars. It appears that Androeme largely takes the place of Oemida in the W. Usambaras (although Oemida also exists there); further investigation is needed to find how much the habits of the two species are paralleled.

Distinction between Oemida and Androeme

Adults: Oemida (Fig. IV) dull brown to yellowish in part; variably infuscated. Scape of antenna with an apical scar limited by a fine curved line (carina). Prothorax with an obtuse tubercle at the middle of each side and with weak elevations (nodosities) above. Length 8–23 mm.

Androeme dull olive-green. Antennal scape. normally rounded. Prothorax without nodosities. Length 11–27 mm.

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* J. O. Evans resigned in March, 1956, and from that date the investigation was taken over by S. J. Curry, Forest Entomologist, Kenya.

Larvæ: Both have much in common especially in having at most a trace of pigmentation at the anterior extremity of the head. However in Oemida (Figs. I and II) the soft ampullæ of the typical abdominal segments are distinctly bilobed; the legs are minute; the ventral surface of the prothorax (eusternum) is triangular. In Androeme the ampullæ are not bilobed; legs are more distinct; eusternum with a pair of narrowly separated, nearly circular nude spaces. Another distinction is that in the larva of Oemida the posterior angle of the head (after removal) is distinctly brown (Fig. II) while in Androeme it is not.

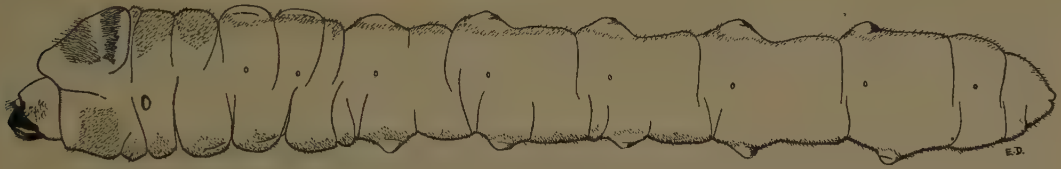

Fig. I.—Oemida gahani. Mature larva (lateral view)

DISTRIBUTION

The known distribution of *O. gahani* recorded in our previous article (1953: 178) requires amendment.

In Kenya there is no alteration; the species is widely spread in the Kenya Highlands.

In Uganda we recorded it from the west side of Mt. Elgon; it has since been reared, on four occasions, from dry wood of *Drypetes* sp. in the natural forest of Kalinzu in the extreme west. No economic damage by this species is yet known from Uganda.

In Tanganyika we found *O. gahani* abundant in hardwood stumps and logs in the Rongai Forest Reserve on the northern slopes of Kilimanjaro up to about 7,000 ft.; we found no evidence of economic attack except an isolated case of a cypress log, of uncertain history, found in a sawmill. It is common in dead wood in natural forest on the east and south slopes of Mt. Meru where damage to cypress plantations at Olmotonyi and Narok is extensive. We found it in old stumps and logs in natural forest at Merera (N. Highlands) and at Nou (Central Tanganyika). The wooden *Cassipourea* structure of the rest camp at Ngorongooro is attacked. In the Mufindi (S. Highlands) area the species was common but only in dead trees and stumps; plantations of cypress and juniper appeared to be free, although apparently suitable scars were present on many stems. From the West Usambaras there are so far two records (both by Insect Ranger Elias): adults were extracted from dead *Syzygium* sp. and from dead parts of a living *Vangueria* sp., both in the Shume forest; in the first case the material sent in by the collector consisted of one *Oemida* and numerous adults of the closely related *Androeme plagiata* Aur.

In S. Rhodesia there is one specimen from Mafungabusi and two from Sabi Valley in the collection of the Department of Research, Salisbury (*teste* D. J. W. Rose, Entomologist); also there are specimens in the National Museum, Bulawayo, from the Vumba mountains 4,000 to 5,000 ft. and from the Chirinda Forest 3,000 ft. (*teste* E. A. Pinhey, Keeper of Entomology).

As we mentioned before the species was first described from the Transvaal. We now have two more records from South Africa both provided by Mr. Pinhey who tells us that the museum at Bulawayo has specimens from The Bluff, Durban, and from Umhlanga Rocks just north of Durban on the Natal coast and collected by Colonel Barker and Bell Morley respectively; these are the only low level records we have so far and the fact that the latitude is 30° is particularly interesting.

There is little doubt that *O. gahani* is much more widely distributed than available records show.

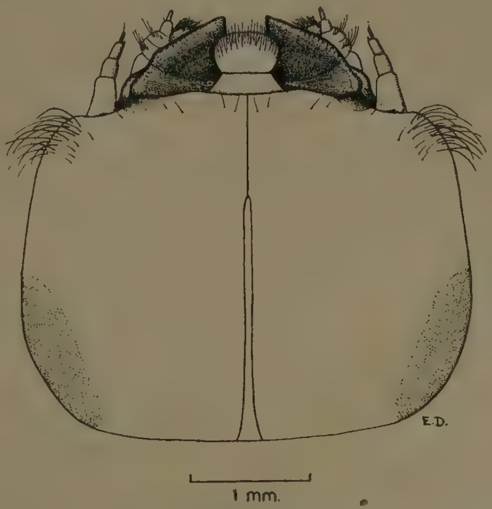

Fig. II.—Oemida gahani. Mature larva. Head (dorsal view)

HOST SPECIES

Hardwoods.—Although pruning in hardwood plantations is systematically carried out, no case of Oemida attack correlated with pruning scars has yet come to light; on the other hand infestation arising from larger damaged areas on living trees is frequent. Oemida has been reared from dead wood of the following in addition to those previously listed (1953: 179): *Acacia, Cassipourea, Clausenia, Croton, Drypetes, Fagara, Grevillea, Lachnopylis, Maba, Schinus, Syzygium, Teclea, Warburgia.* It is probable that most species, as logs, stumps, etc., will support the insect. Young larvæ inserted into dry bamboo five years ago are still living. *Gymnosporia luteola,* common in some areas, seems invariably to be very heavily attacked after death.

Softwoods.—Scars on living *Cupressus* spp. and on *Juniperus procera* are oviposition sites. No attack on pruned living *Pinus* spp, is so far known. Logs and sawn wood of *Juniperus, Cupressus, Podocarpus* and *Pinus* are attacked.

NOTES ON BIOLOGY

Notes were given previously (1953: 179). The shortest life-cycle since recorded, in moderately moist cypress is 14–15 months; adults approached the maximum size. As we said before, in dry structure podo larvæ can live for years and may produce miniature adults.

We referred (1953:180) to 3.25 cubic feet of attacked *Lagunaria,* already showing numerous emergence holes before caging. After six years caging, 1,515 adult Oemida emerged; there was considerable damping down of emergence in the last three years but the pattern remained similar: emergence throughout the year but peaks corresponding with the two rainy periods in each (Fig. III).

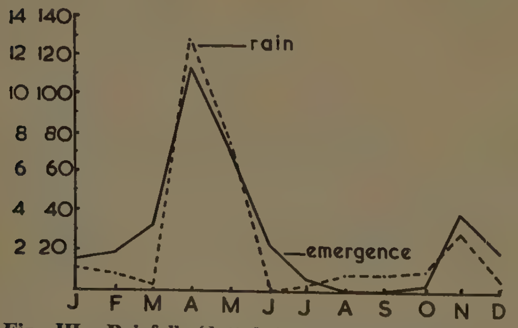

Fig. III.—Rainfall (dotted line) and emergence of adults (entire line) from one cage in 1952

It seems pretty certain that an Oemida which has completed its life history in a living cypress cannot work its way out unless its pupal chamber lies beneath an externally evident deadwood scar: we have on several occasions found dead beetles underlying living sapwood, sometimes under occluded pruning scars. We have in fact so far never seen emergence holes through living sapwood.

Attacked stems from living cypress (Fig. V) and from living juniper (Fig. VI) are shown.

A piece of attacked one-inch podo flooring is shown in Fig. VII.

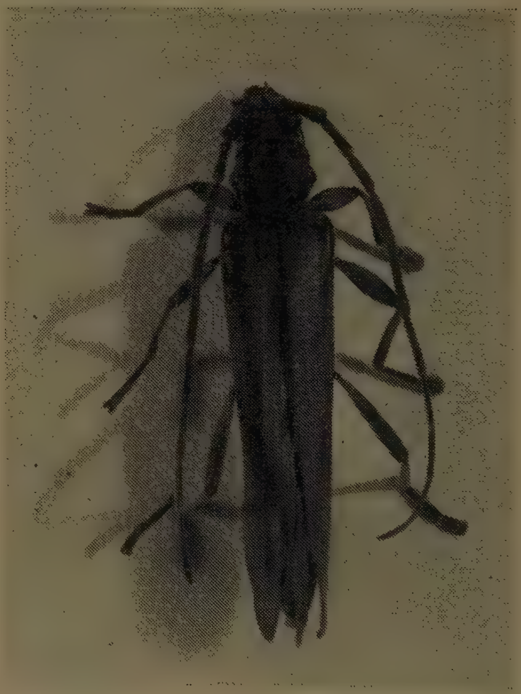

Fig. IV.—O. gahani, adult, length ¾ in.

INCIDENCE OF ATTACK IN PLANTATIONS

We have found no way of determining (except of course when emergence holes are visible on dead scars) whether a living tree is attacked or not other than by felling and sawing. It is obviously desirable to estimate the incidence of attack in a particular plantation and any changes in the course of time.

At first we attempted to estimate the percentage of trees attacked by examining the cross-cut surfaces of 12-foot logs in the forest during thinning operations. This proved to lead to considerable under-estimation. A much closer approximation to the truth is attained by sawing into planks at the mill, an operation especially difficult in the sorting out of logs whose identification markings become so often concealed by mud and abrasion. We thought that there might be some correlation between the percentage attacks shown from butt-end counts and from plank counts. Evans carried out a test with 300 cypress trees from nine different compartments and found that while a cross-cut count gave an incidence of 18 per cent a plank count gave an incidence of 34 per cent trees attacked; nearly half of the attack had been missed in the cross-cut count.

It would seem worthwhile further to test this proposition (that an approximation to true percentage incidence is obtained by doubling the "cross-cut" count in the forest) to approach statistical significance.

The estimation of percentage *logs* attacked in a given plantation, is comparatively simple since no correlation with the parent tree is wanted at the mill.

If it is required to sample a plantation this should not be based on thinnings which may lead to over-estimation.

PROTECTIVE MEASURES

Various aspects of control were discussed in the first report (p. 181) and necessarily long-term experiments are in progress.

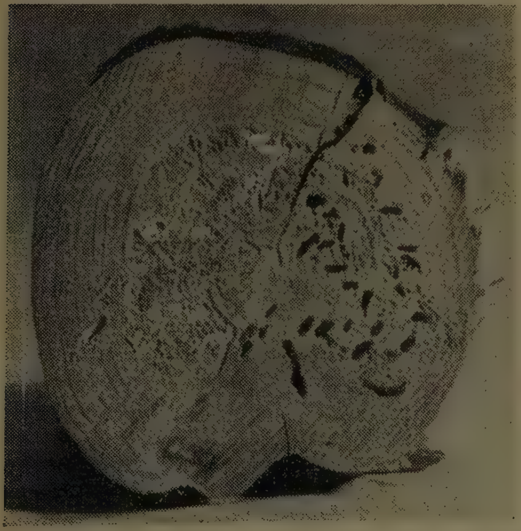

Fig. V.—Section from attacked living cypress, diam. 7 in.

Possible Immunity of Living Pines

We mentioned before (p. 179) that no Oemida attack on healthy pine was known up to 1953; four years later the position remains the same. The three forest departments were requested to report any case as a matter of urgency and hitherto no record has reached us. So far only a comparatively small quantity of pines has been through the mill: 120,00 cu. ft. in the period 1952–55 according to the Utilization Office, Kenya Forest Department, and much more must be sawn before the immunity or otherwise of living pine can be reasonably decided.

In one experiment by Evans 50 Oemida larvæ, about half-grown, were inserted into holes drilled into partly occluded pruning scars in living *Pinus patula* and 50 into similar scars on *Cupressus lusitanica*: nine days later all larvæ in pine had died whereas in cypress 25 larvæ were actively tunnelling.

In another experiment five larvæ were inserted into large pruning scars (about two years old) on a 12-years-old *Pinus radiata*; examined eight months later only one larva was found alive, having made a tortuous gallery in the dry outer inch of the scar; deeper than that the contained branch was resinous. Larvæ similarly inserted into cypress scars bored through the knot into the heartwood of the tree.

These experiments, which require repetition, suggest that larvæ flourish in the dead wood interior to the scar in cypress the contrary being the case with pine, apparently owing to the latter's copious supply of resin. When pine branches are pruned the scar surface becomes covered with resin within a fortnight. If immunity of living *Pinus* spp. from Oemida is confirmed and we feel that it will be, the problem could be solved by concentrating on the pines; the Kenya Forest Department has in fact already speeded up its planting programme in favour of pines.

It is emphasized that pine logs or sawn timber are far from immune.

Animal Damage

In some areas barking of cypress, leading to Oemida attack is serious. In parts of the Nyeri Division for example: "when it occurs Sykes monkey damage by barking is the worst form of damage that we have to cypress. During the war years I saw tens of thousands of trees so damaged and I have since seen the same damage as the contributory cause to both canker and Oemida attack. In the worst instances at Chehe we even resorted to clear-felling when monkey damage led to such bad attacks that the crop was not worth keeping to grow to maturity." (Douglas Leakey *in litt.*). A campaign against the monkeys was successful at the time.

Electric fences against elephants seem to be efficient. In one area in Tanganyika the local population seem to have the habit of chopping off bark from plantation trees: here Oemida attack was high.

Pruning Operations

The Silviculture Specialist Committee is carrying out investigations at Muguga and in all three mainland territories on the effect of season of pruning on the rate of occlusion of pruning wounds and on the rate of occlusion of different sizes of wounds. We have observed that a very small proportion of stems under 4 in. in diameter contain axial "dead wood" suitable for larval development; if pruning were done sufficiently early before the formation of "heartwood" in the main stem Oemida risk should be lessened, first through the smaller and rapidly occluded scars and second through the lack of favourable feeding zones for the larvæ. There are some practical aspects which are being studied by the Silviculturists.

Owing to serious interference with forest operations due to Emergency conditions in recent years there are large areas of plantations in Kenya long overdue for pruning; the choice of action seems to lie between not to prune at all or to prune and apply dope.

Abolition of Pruning

Two more examples of partly unpruned cypress plantations were examined at Kitiro in Kenya and at Narok in Tanganyika; in each pruning had been carried out to about 7 ft. when the trees were young. In the former (? 14 years old) the plantation had been evenly treated; no Oemida was found in unpruned parts of the trees, although attack was present in the basal and pruned parts: a few dead trees were badly attacked. In the Narok plantation (about 20 years old) selective pruning had been carried out in the past, but many unpruned stems remained. We were informed by the sawmiller that abundant Oemida was present in the pruned trees. A sample of 20 of the unpruned stems was sawn into scantlings and carefully examined: no Oemida damage was found. The stems had at least 15 ft. of dead branches, were moderately close grown (about 8 ft. × 8 ft.) and knots were small and firm. In both cases the sawmillers pronounced the timber from these samples to be good and readily saleable.

An interesting case is reported by J. P. W. Logie, from Marmanet, Thomson's Falls Division, Kenya: a total sample of 100 trees was examined from four plantations (shown by previous thinnings to be heavily infested): in three of these with a normal pruning history Oemida was distributed throughout the stems while in the fourth "the case is interesting since, apart from an early pruning, it had been left unthinned and unpruned until recently. All the Oemida was in the butt logs." Information accumulated so far indicates that abolition of pruning would go a long way towards answering the Oemida problem.

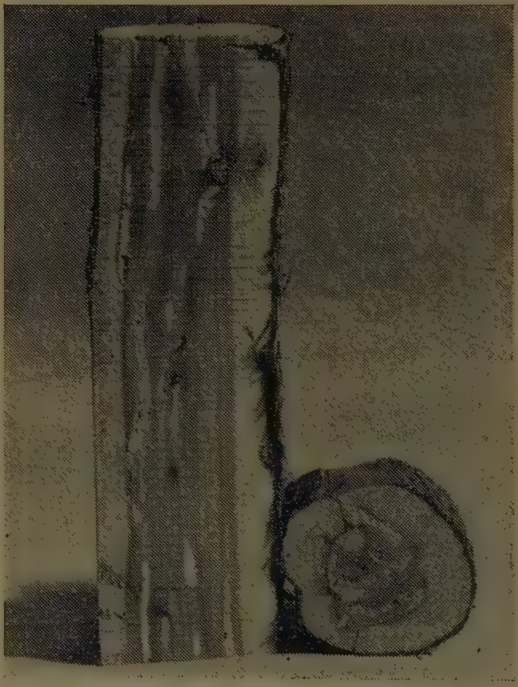

Fig. VI.—Section from living juniper, diam. 3 in.

Doping Scars

Evans has tried out numerous possible dopes on scars to prevent oviposition; several of these are promising, but sufficient time has not elapsed to prove efficiency. He has also devised suitable apparatus for application should suitable dopes be proved. This troublesome method of protection may well become necessary if pruning of cypress be considered essential.

DISPOSAL OF AFFECTED TIMBER

Cypress logs may be found to be attacked in the forest or later at the mill; often a quantity of sound timber can be extracted. We previously recommended that damaged planks should be burned unless it were found an economic proposition to sterilize them (preferably in thin dimensions which are easier to treat) with a view to use for crating, etc. As an alternative to pressure impregnation, heating on kiln seasoning lines may be worth consideration and the formulation of a schedule for temperature, humidity and thickness should not be difficult. Affected logs, or most of them, could be so treated as opposed to being left in the forest.

If industries such as paper and hardboard making are started, there should be an outlet for cypress plantations, including attacked trees. We are not aware if our previous suggestion about charcoal making has been tested; even if the product were of poor quality it should lead, at least, to clearing up thinnings.

Fig. VII.—Piece of one-inch podo flooring showing emergence holes of adult, and, where surface stripped, appearance of interior

STRUCTURAL TIMBER

Podo, cypress and pine, of any dimensions require early chemical treatment, e.g. by pressure impregnation. More superficial treatment such as with pentachlorophenol or with certain proprietary formulations have been reported on favourably in other but analogous connexions; in these cases woods liable to crack after treatment may lead to trouble.

TIMBER FOR EXPORT

In making up a parcel: (1) all timber showing any Oemida gallery (i.e. whether showing live borer or not) should be excluded, (2) timber should be sprayed or dipped with a contact insecticide (e.g. B.H.C. or D.D.T.) to prevent any chance of oviposition afterwards and (3) timber should be shipped as early as possible.

OEMIDA IN STRUCTURAL TIMBER

As we recorded in our previous report, structural timber of podo (*Podocarpus* spp.) is particularly liable to attack in Nairobi and its neighbourhood. A more recent case is that of a large school whose podo roof, about 25 years in place, was found to be attacked; a sample 6 in. × 3 in. beam showed an average of 12 emergence holes per 36 sq. in.; the inside was badly damaged and in fact in a dangerous condition. It appears that superficial application of a wood preservative had been considered after emergence holes had been detected: this would not only have been useless but dangerous, in giving a false sense of security. A chemical treatment should aim at prevention of attack and therefore should be applied before installation.

In another case a floor of juniper heartwood, about 20 years old, showed typical Oemida emergence holes in regular lines about 3 ft. apart; these lines were found to coincide with underlying and badly attacked podo supports; the beetles had bored through the juniper to the exterior without feeding on it.

It should not be assumed that podo is the only susceptible structural timber, for it is pretty certain that had, for example, cypress and pine been available 20 years or so ago they would have suffered. Nor are hardwoods immune. In June, 1955, Mrs. E. J. Brown reported that the log cabins of the rest camp, Ngorongoro National Park, Tanganyika, were badly bored: a sample of the wood (*Cassipourea elliotti*) collected by her produced Oemida adults after caging. We found the woodwork of the old fort at Arusha, fortunately due for demolition, showing large numbers of Oemida emergence holes.

However we do not consider this aspect of Oemida particularly alarming, provided suitable methods of wood preservation are applied initially, to softwoods at any rate. The precise food requirements of Oemida have not been determined and physiological studies on these lines may well prove profitable. A large beam of podo may show quite distinct zones of immunity and susceptibility; a brown zone immune and a pale zone liable to attack.

It may be well to emphasize here that infestation starts in the structures and is not necessarily brought in from the forest.

ACKNOWLEDGMENTS

We are much indebted to Mr. E. A. J. Duffy for Figs. I and II, to Mr. A. J. Searle for Figs. IV, V and VI and to Mrs. A. K. Ryland for Fig. VII.

REVIEW

APPLIED ANIMAL NUTRITION, by E. W. Crampton. Published 1956 by W. H. Freeman & Co., San Fransisco at $6/50 (478 pages, 15 charts, 86 tables and 28 figures).

The author sets out to bring together the science of animal nutrition and the practical feeding of farm livestock. Consequently the subject matter ranges widely from "rules of thumb for feeding young dairy cattle" to a brief discussion of the part played by nutrients in the Krebs citric acid cycle, and other aspects of intermediary metabolism.

This book is divided into four sections. Section I discusses the foodstuffs in general terms. Definitions and names are given, not all of them familiar to the reader on this side of the Atlantic. However, they serve to avoid ambiguity and misunderstanding of the later discussions. There is a lucid and critical chapter on the chemical composition of foods, and the values and limitation of these analyses in terms of the animal. The European (starch equivalent) and American (total digestible nutrients) systems of assessing energy values are well described and compared, as are protein values, and methods for digestibility determinations. Section II elaborates on the nutritional requirements of animals for maintenance, growth and other forms of production, using the T.D.N. system: The commonly held view that poor quality diets are so because of protein deficiency is criticized, and evidence is brought that energy deficiency (T.D.N.) is more commonly the major factor.

There is a short but useful chapter on the requirements for minerals and vitamins, and on the effects of antibiotic supplements.

Chapter 9 gives feeding standards for animals in the light of these requirements.

The last two sections discuss the nutritional characteristics of some of the common feedstuffs, and how these can be formulated into rations for the various species and classes of farm livestock.

A wide range of ration formulæ is given. It is shown how these are arrived at and also how alternative feedstuffs can be suitably substituted. This latter is especially useful as many of the feedstuffs, in particular concentrates, are unfamiliar to or unavailable in East Africa.

Three appendices cover miscellaneous feeding guides; feedstuffs control and legislation in Canada and U.S.A. showing how both the farmer and the reputable feedstuffs manufacturers are mutually protected; and finally brief tables on feed composition.

This book will be invaluable to the serious student of animal nutrition as a logical approach to the business of feeding animals, whilst people concerned with the practical aspects of this topic will find much useful information and advice, and stimulating discussion.

The tables and figures, and the mathematical and statistical treatments presented in the text are easily understandable. However, some sections are not clear concerning the species being discussed, the danger of this being the transposition of one set of results to another species of animal whose digestive physiology is quite different. The habitual use of the word "herbivore", when "ruminant" is usually meant is rather irritating and also could be misleading.

A quotation from page 387 will serve to indicate that the writer, although a scientist, is not unaware of the art of feeding animals: "Successful livestock feeding is not learned out of a book, and there are many skilled feeders who know little or nothing of the science underlying the feeding practices which they successfully employ. There are, nevertheless, basic principles involved in livestock feeding, and some of these can be reduced to rules and guides that will be useful to feeders who lack the experience or apprenticeship otherwise necessary".

G. D. P.

REVIEWS

FLORA OF TROPICAL EAST AFRICA, MENISPERMACEÆ by G. Troupin, price Sh. 3, pp. 1–32 and 6 figures, 1956. Published under the authority of the Secretary of State for the Colonies by the Crown Agents for Oversea Governments and Administrations, Millbank, London.

Calumba Root is the source of a drug containing two yellow crystalline alkaloids, jateorhizine and palmatine, and two colourless, crystalline, non-alkaloidal bitter principles columbin and chasmantherin, and is used in medicine as a stomachic and bitter tonic. It is obtained from *Jateorhiza palmata* (Lam.) Miers, a lofty climbing plant with annual herbaceous stems and swollen fleshy roots. It is found in Kenya, Tanganyika, Nyasaland, Portuguese East Africa, the Gold Coast and Mauritius, and the main sources of commercial supply are from wild plants in Southern Tanganyika and Portuguese East Africa.

Jateorhiza is a member of the Menispermaceæ, and this family has now been completed for the *Flora of Tropical East Africa* by Dr. G. Troupin, of the Jardin Botanique de l'Etat, Brussels, and translated into English from the French text by Mr. J. P. M. Brenan, of the Royal Botanic Gardens, Kew.

Ten genera with 30 species are recorded from East Africa and they consist of twining or rarely erect shrubs or small trees in which the female flowers are found on one plant and the males on another. For this reason Dr. Troupin has provided two keys to the genera which should facilitate the running down by a collector to a genus should he collect specimens of one sex. Three genera are represented by only one species, but the largest in East Africa, *Cissampelos,* contains eight species.

The family and genera are described in detail, and where there are more than one species in a genus keys are provided and each species is fully described. The geographical distribution for each is given, along with that outside our region, and specimens of collectors are quoted for the different areas in which they are found in East Africa, together with the plants' ecological habitat. Synonyms are given where a species has been described under more than one name.

Six full-page figures are provided, and these illustrate in line drawings seven out of the ten genera dealt with, so a beginner studying the family should have little difficulty in learning the names of the species with which he comes in contact. Five of the drawings are by Miss E. M. Stones and one by Mrs. Milne-Redhead, and they do credit to both artists as the flowers are small and inconspicuous and they have drawn the parts of the flowers and fruits in much detail.

The author is to be congratulated on his study of this difficult and complicated family, no easy task as the male and female flowers are to be found on quite separate plants.

Chemically the family might well repay study, as there are members other than *Jateorhiza palmata* that are of medical use to Africans, and from a fibre point of view *Cocculus hirsutus* (L.) Diels with its thin stems provides the material for the very fine basket chairs and tables woven by the peoples bordering the western shores of Lake Nyasa in Nyasaland.

An index to the genera and species together with their synonyms is provided at the end. The part is available at all Government Printers in East Africa and the Uganda Bookshop, Kampala.

P. J. G.

FLORA OF TROPICAL EAST AFRICA, RHIZOPHORACEÆ, by John Lewis, price 2s. 6d., p.p 1–20 and five figures. 1956. Published under the Authority of the Secretary of State for the Colonies by the Crown Agents for Oversea Governments and Administrations, Millbank, London.

All down the coast of East Africa in deeply indented and sheltered bays and in the mouths of rivers are to be found mangrove forests which play an important part in the economy of the coastal peoples and are a source of revenue to governments.

Ecologically these forests are best described as evergreen saline swamp forest, their chief constituents being the mangroves *Rhizophora, Ceriops* and *Bruguiera.* All are important economically as they are the source of the building poles known as *boriti* used on the coast in native and Arab buildings and exported in vast quantities to the Persian Gulf.

These mangroves have now been dealt with in the *Flora of Tropical East Africa, Rhizophoraceæ.* The family is represented in East Africa by five genera, the three already referred to and also the genera *Cassipourea* and *Anisophyllea.* A botanical description of the family is given; they are all shrubs and trees and three of the genera, *Rhizophora, Ceriops* and *Bruguiera* are viviparous, that is the seeds germinate or sprout when the fruits are still attached to the parent plant.

A key to the genera follows, then each genus is described together with a description of the species in the case of the genera *Rhizophora, Ceriops* and *Bruguiera* as these contain only one species each. In *Cassipourea* and *Anisophyllea* there are more than one species and keys to them are provided. Under each species references to the more important literature are given, followed by a full description of the species.

After the description the geographical range in East Africa and elsewhere is given as well as quoting collectors' specimens from each territory in East Africa.

The genus *Cassipourea* when last monographed in 1925 contained 64 species and is distributed from British Guiana in the West to Ceylon in the East. Mr. Lewis records eight in East Africa and in his study of the genus he has reduced quite a number of the species enumerated in the earlier monograph. The Pillar-wood, "Muzaizi", hitherto known as *Cassipourea elliotti* (Engl.) Alston has now to go under the name *C. malosana* (Baker) Alston.

Anisophyllea is represented by three species in the Flora, two of them being found in *Brachystegia-Isoberlinia* woodland in Tanganyika, Belgian Congo, Northern Rhodesia and Nyasaland; the third *A. obtusifolia* Engl. and Brehm., is found only in evergreen rain forest in the Eastern Usambara Mountains, Tanganyika. It has, however, a close relative in West Africa, *A. laurina* R.Br. ex Sabine, which occurs in Portuguese and French Guinea and Sierra Leone. This genus as a whole is widespread in tropical Africa, with a few species in India and the Malay Peninsular, but it has also been discovered quite recently in tropical America.

In this part all five of the genera are illustrated by full-plate line drawings, four of them by Miss E. M. Stones and the fifth by Miss D. R. Thompson, so that anyone with the aid of them should be able to find the genus they are looking for provided they are in the right family.

An index to all the species referred to is provided at the end and both the author and the artists are to be complimented on the completion of a further part of this important and long-wanted flora.

Biologically the genera *Rhizophora, Ceriops* and *Bruguiera* are extremely interesting in their mode of reproduction and distribution as they are to be found in habitats suited to them on all tropical shores of the world and in their habitats they are associated with certain plants, animals, birds, insects, fishes and shells. The mangrove formations in East Africa still require further study ecologically and the Forest Departments of both Kenya and Tanganyika have a forest officer whose main charge is that of looking after mangrove forests, the produce from which would be rapidly over-exploited. In 1955, in Kenya, 431,619 mangrove poles valued at £35,286, and in Tanganyika 125,988 valued at £10,168 were exported. Mangrove bark used as a tanning material is also of value and £4,200-worth was exported to the United Kingdom from Kenya whilst in Tanganyika the bark brought £7,161 of which £5,404 came from the United States. Charcoal is also obtained from mangroves but the value of the poles is far greater than that of charcoal.

Pillar-wood, *Cassipourea malosana,* was thought to be of value for telegraph poles but was found to be useless owing to its extremely perishable nature even when impregnated with creosote in pressure cylinders and its main use seems to be for heavy tool handles.

This flora can be obtained from the Uganda Bookshop, Kampala, and all Government Printers in East Africa. P. J. G.

BANANAS AND BOTANY

Anyone who is interested enough to examine the flowers of a banana can learn all about its structure from Leslie S. Cobley's book *An Introduction to the Botany of Tropical Crops**. This gives a full-page figure of a flower and fruits, well labelled, showing all the parts of the banana *Musa sapientum.* In the text we learn that "Bananas are by far the most important of the tropical fruits" and that "The fruits eaten as dessert, without any cooking process, are called bananas, whilst the more starchy types which need cooking before they can be used as vegetables are called plantains. There is no specific difference between these two groups of varieties". With this definition I hope pedantic botanists will be satisfied because even dessert bananas are cooked when fresh and there is the dried banana and banana flour and one is often posed with the question what is a banana and what is a plantain?

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* *An Introduction to the Botany of Tropical Crops*, by Leslie S. Cobley, B.Sc., A.I.C.T.A., pp. 1-xv, 1-357, pl. 82 and Figs. 66, with Indices, price Sh. 37/6, Longmans, Green & Co., London, New York and Toronto.

The book is divided into 12 chapters in which the botany of cereal crops, sugar cane, vegetable fibres, the oil seeds, the leguminous crops, starch storage crops, the spices, the beverages and drug plants, the cultivated fruits, vegetable crops, rubber and finally the essential oil crops are dealt with.

Since the cereal crops all belong to the family Gramineæ, the botany of the family is discussed and illustrated, then rice (*Oryza sativa*), grain sorghums (*Sorghum vulgare*), maize (*Zea mays*), Bulrush millet (*Pennisetum typhoideum*), Foxtail millet (*Setaria italica*), Panicum millet (*Panicum* spp.), Japanese Barnyard millet (*Echinochloa frumentacea*), Finger millet (*Eleusine coracana*), and finally Hungry rice (*Digitaria exilis*) are described. Under each, brief mention is made of origins, economic importance, botanical types, ecology and distribution. These are followed by a botanical description of the plant as a whole and the flower structure in particular, many of them, but not all, illustrated by line drawings of the flower and flower structure.

At the end of each chapter the author gives a list of references some of which are grouped, as in the case of the cereal crops, into general, rice, dura, maize and the millets by means of which a student can pursue his studies on any particular cereal crop.

With the classification used by the author certain plants have been separated, for example the banana (*Musa sapientum*) is dealt with in the cultivated fruits whilst Manila hemp or Abaca fibre derived from *Musa textilis* is dealt with under vegetable fibres. The flower structure of the former is well illustrated whilst the latter is not, yet surprisingly no cross-reference in the text is made by the author under either.

Under the oil seeds (divided into drying oils and the non-drying oils) the author, in linseed oil, deals with *Linum usitatissimum* as an oil plant but not as a fibre plant, although as such it was part of East Africa's war effort in the past two world wars. Neither is derris or pyrethrum mentioned, the latter being an important economic crop in East Africa.

However, I consider the author has attained his objective, which was to survey the botanical features of the more important tropical crops, and the book is designed mainly for use as a text book by the increasing number of agricultural students in the tropics and elsewhere.

The price is very reasonable and the book should be possessed by all students who are going to take up tropical agriculture as a career. Even forestry students who propose to work in the tropics should have a copy amongst their work-books to enable them to have a botanical knowledge of the crops they will meet within the course of their work.

In spite of the book being well illustrated with 66 original drawings and diagrams and 82 very good photographs, I wish there were more of the former, so that a student could have botany, a very boring subject to most, without tears, and perhaps in the next edition the author will provide line drawings and diagrams of all the species he describes that are not closely related generically.

The book concludes with a list of books for further reading and general reference and there are two indices, one for botanical names, the other a general index, this covering seven pages.

Whilst the author's nomenclature is fairly up to date I notice: *Furcraea gigantea* should be *F. fœtida* for Mauritius hemp; *Oreodoxa oleracea* is now *Roystonea oleracea* for the cabbage palm, a source of sago, and *Pimenta acris* is now *Amomis caryophyllata,* the source of bay oil. These slips are unavoidable because the botanists, in an attempt to bring botanical nomenclature in line with international rules of botanical nomenclature are having to delve back into early botanical literature and examine type specimens. Even I myself, after nearly 30 years' study of the East African flora, am having to relearn my flora all over again on account of the many name changes that are being made and published almost daily in connexion with the taxonomic work that is now proceeding on the tropical African flora from the west to the east coast of tropical Africa.

P. J. G.

THE STORAGE OF SEEDS FOR MAINTENANCE OF VIABILITY, by E. Biasutti Owen. Bulletin No. 43 of the Commonwealth Bureau of Pastures and Field Crops. Published by Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England. 1956. Price Sh. 20.

The introduction states "Some disappointment may be experienced by those who expect to find practical instructions given here for storing seeds". Considering the title of this book, that disappointment is not surprising. However, it does contain a most useful mass of information for the scientific worker who is interested in this field. In East Africa it will have little appeal except to the specialized worker who wants a review of past experimental work on seed storage. The results of a few experiments have immediate practical application, to quote "Barton . . . who investigated the influence on viability of the material employed for packing onion seeds, found that cans with tight fitting lids, which constitute air-tight containers, were far superior to the ordinary kraft-paper seed envelopes for maintaining the viability of onion seeds after their removal from their original storage room". Regarding mites, an interesting paragraph states "While insects feed indiscriminately on the whole grain, mites feed only on the germ and thus ruin the grain for seed purposes . . . The maximum temperatures which mites are able to withstand are lower than those for most insects. Mites are particularly sensitive to the humidity of the atmosphere in which they live; thus the flour mite (*Tyroglyphus farinæ*) cannot survive if the relative humidity is below 60 per cent. Between 60 and 70 per cent it either dies or remains static, and above 75 per cent it multiplies rapidly". Pre-sowing treatment of seeds is hardly dealt with, and forest tree seeds are completely omitted.

W. B. M.

THE CULTURE AND MARKETING OF TEA, by C. R. Harler. Oxford University Press. Second Edition. 1956. Price Sh. 25.

A new edition of Dr. Harler's book is welcome. It is almost the only work now in print which affords a broad survey of the tea industry and it can be recommended to all who require a sound introduction to most aspects of tea planting, manufacture and marketing.

The first part of the book comprises six chapters devoted to the tea plant, tea production, the chemistry and pharmacology of tea. A good account is given of developments in these subjects during the 23 years since the first edition of this book appeared, a period which has seen great progress in the application of science to the tea industry. Only upon pests and diseases is the treatment rather inadequate.

The second part reviews in nine chapters the tea countries of the world. A new chapter on tea in Africa gives, within its necessarily restricted scope, an adequate and fair picture of the present position. It might be mentioned, however, that the Tea Research Institute of East Africa is not (as stated on page 221) a "Government research station", but is financed entirely by the industry.

The third and last part deals with the marketing side of the industry; the chapter on "Tea Tasting", with its glossary of tea-tasters' terms will be found of much interest.

A few minor errors and misprints have been noted, including the rather surprising mispelling more than once of the name of the senior botanist of the Indian Tea Association's Scientific Department. ("Whyte" instead of "Wight".)

In these days many books on specialized subjects are overweighted with references, and are, in fact, monographs for reference rather than for consecutive reading. The present work goes to the other extreme of being entirely undocumented; more than that, it shows a curious reticence about the names of individual research workers. For example, an extended abstract is given of "an important work" on tea chemistry published in 1944, without mentioning the author (the late Dr. A. E. Bradfield). Again one would have expected Dr. T. Eden's name to be mentioned in connexion with the manurial trials initiated by the Tea Research Institute of Ceylon in 1931, since they were the first in which the then novel statistical methods were applied to tea. The book is therefore rather one for the general reader than for the agricultural research worker.

The author has digested into very readable form a great deal of information, based upon his own experience over many years and in various countries, as well as upon wide study and reading. The book can be recommended to all interested in tea, whether as producer or consumer.

R. C.

Dairy Produce, 1956. Obtainable from H.M. Stationery Office, or from the Secretary, Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1. Price 5s. (5s. 7d. post free).

This review shows that the upward trend in world production and trade in dairy produce has continued, with a large part of the increase in Commonwealth countries. Both New Zealand and Australia enjoyed favourable seasons in 1955–56 and the increase in their exports of butter brought world trade in this commodity to the highest level since 1950 although it remained about one-fifth below the pre-war figure. The main factor underlying the rise in milk production is the continued expansion in milk yields per cow; in the United Kingdom, for example, the average yield in 1954–55 was estimated at 615 gallons compared with 542 gallons pre-war.

While the Commonwealth accounts for a very large share of world exports of dairy produce, over one-half in the case of butter, its import demands are growing also. The United Kingdom remains the world's largest importer of butter, cheese and milk powder. Malaya and other Colonial territories are importing increased quantities of canned milk and there are signs that the remarkable expansion in imports of milk powder into India may be followed elsewhere. Nevertheless, the exporting countries of the Commonwealth have been able to provide a growing share of the requirements of the importing countries, as is illustrated by the fact that for all milk products, other than cheese, the Commonwealth is a net importer on a much smaller scale than before the war. The improvement in the Commonwealth's trading position with the rest of the world has been reinforced by the rise in output of manufactured milk products in the United Kingdom.

Butter and Margarine

The rise in butter exports from New Zealand and Australia has been accompanied by a higher rate of disposals from surplus stocks in the United States, a large part of which has been in the form of free donations for welfare purposes in many countries and has not passed through normal trade channels. Nevertheless, the United States also made heavier commercial sales for export in 1955, as, to a lesser extent, did Canada and France, which more than offset a reduction in butter exports from the principal Continental exporters. Most of the increase in Commonwealth exports of butter has been directed to the United Kingdom where the lower average price levels of the past two years have encouraged an increase in butter consumption at the expense of margarine, although butter consumption remains well below the pre-war level and margarine consumption above it. A graph, illustrating movements in butter and margarine consumption in the United Kingdom since 1920 (page 6) illustrates how, in the period between the wars, consumption of both products varied according to the price of butter and it seems that similar relationships are again being established now that rationing and controls have ended.

Cheese

The Commonwealth has not shared in the general increase in world cheese production in recent years, Canadian output being well below the pre-war level and production in New Zealand and Australia being affected by a switch to butter and its by-products. A marked rise in cheese prices in the United Kingdom in the last year has been followed by some recovery in output in New Zealand and Australia which supply the bulk of the United Kingdom's imports; cheese production in the United Kingdom itself in 1956 has shown a pronounced increase.

Condensed Milk

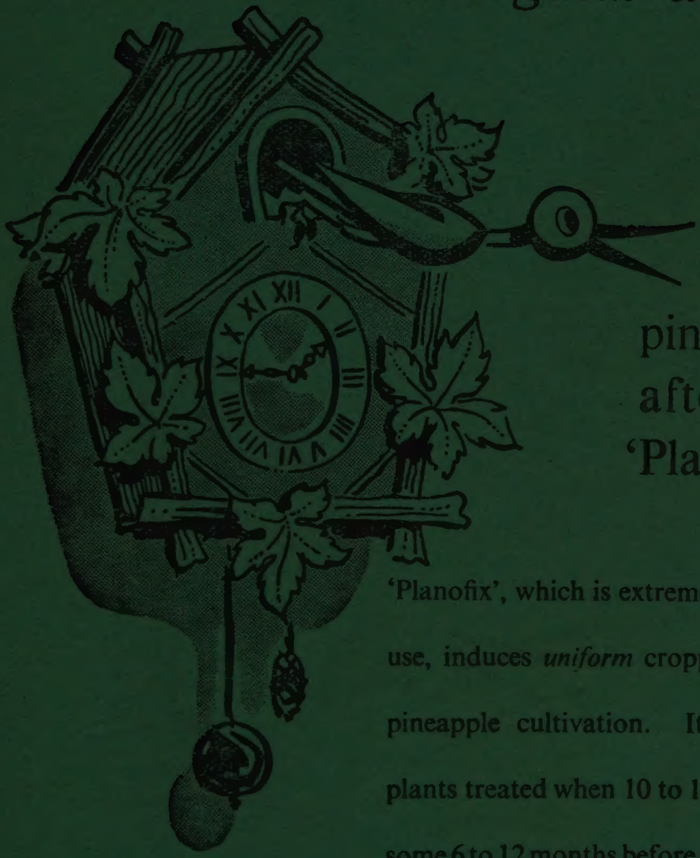
The downward trend in world production and exports of condensed and evaporated milk was reversed in 1955. A rise in the Commonwealth's share in world trade was due largely to the expansion in output in the United Kingdom which reduced its imports to negligible proportions and also became the largest Commonwealth exporter. Other Commonwealth countries, including Malaya and territories in the West Indies, are major importers of condensed milk.

Milk Powder

The increase in production of milk powder in recent years, and in particular of skimmed milk powder, has been greater than for any other milk product. While Commonwealth countries probably provide more than half of the supplies entering world trade on a commercial basis, very large quantities of skimmed milk powder have been available for export out of surplus Government stocks in the United States, either as free donations or under various schemes involving reduced prices or payment in local currencies. With the exception of the United Kingdom, the principal commercial market for Commonwealth supplies, and India, whose requirements have shown a remarkable expansion, Commonwealth countries are not among the major importers of milk powder nor have they been the recipients of shipments on special terms from the United States.

Eggs

The pre-war level of world trade in eggs was exceeded in 1955, about three-fifths of total exports coming from the Netherlands and Denmark; the Commonwealth's share was 5 per cent. The downward trend in United Kingdom imports has continued and has been accompanied by a growth in production which accounts for about 90 per cent of total supplies. In contrast, imports into Western Germany have risen to nearly twice the pre-war level and far exceed those into the United Kingdom, while Italy and other Continental countries have also increased their imports.



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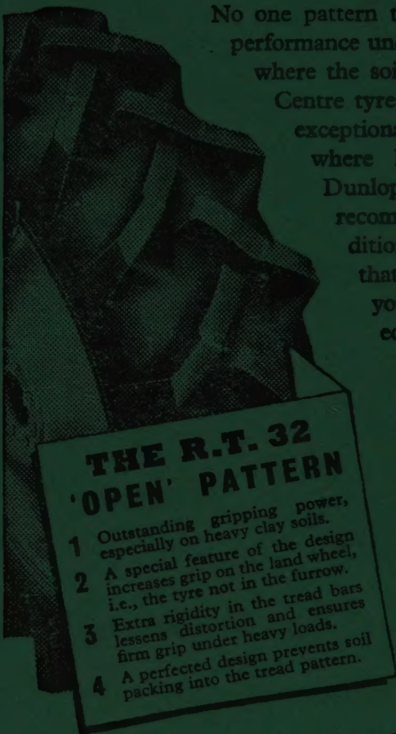

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